

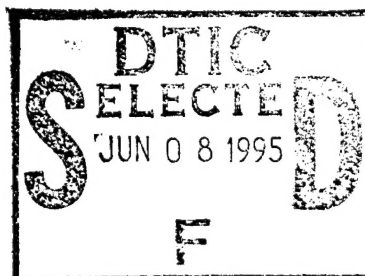
WL-TR-95-3004

TRANSPORT AIRCRAFT COCKPIT PROGRAM:
AN EVALUATION OF A BASELINE COCKPIT
CONFIGURATION PROMOTING CREW REDUCTION
IN TACTICAL TRANSPORT AIRCRAFT

ERIC J. MARTIN
JOSEPH J. CAVALLARO
JOHN A. HASSOUN

VEDA INCORPORATED
5200 SPRINGFIELD PIKE, SUITE 200
DAYTON, OH 45431-1255

1 LT TOM R. CONKLIN
USAF
WL/FIPC



APRIL 1994

FINAL REPORT FOR 04/01/93-01/31/94

"Original contains color
plates: All DTIC reproductions
will be in black and
white"

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

FLIGHT DYNAMICS DIRECTORATE
WRIGHT LABORATORY
AIR FORCE MATERIEL COMMAND
WRIGHT PATTERSON AFB OH 45433-7562

DTIC QUALITY INSPECTED 3

19950606 024

NOTICE

When government drawings, specifications, or other data are used for any purpose other than in connection with a definitely government-related procurement, the United States Government incurs no responsibility nor any obligation whatsoever. The fact that the government may have formulated, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise in any manner construed, as licensing the holder or any other person or corporation, or as conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related there to.

This report is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

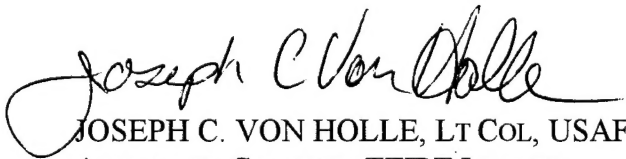
This technical report has been reviewed and is approved for publication.



RICHARD W. MOSS
CHIEF, COCKPIT DEVELOPMENT SECTION
WRIGHT LABORATORY



DR. JOHN M. REISING
SENIOR HUMAN FACTORS PSYCHOLOGIST
PILOT VEHICLE INTERFACE TECHNOLOGY
SECTION
WRIGHT LABORATORY

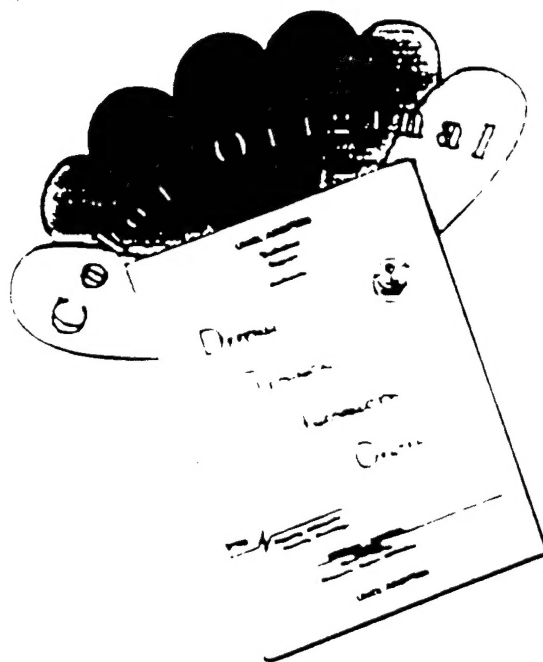


JOSEPH C. VON HOLLE, LT COL, USAF
ADVANCED COCKPITS TTIPT LEADER
WRIGHT LABORATORY

If your address has changed, if you wish to be removed from our mailing list, or if the addressee is no longer employed by your organization, please notify Wright Laboratory; Flight Dynamics Directorate; WL/FIGP Bldg 146; 2210 Eighth Street Ste 1; Wright-Patterson Air Force Base, OH 45433-7511 USA

Copies of this report should not be returned unless return is required by security considerations, contractual obligations, or notice on a specific document.

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF COLOR PAGES WHICH DO NOT REPRODUCE LEGIBLY ON BLACK AND WHITE MICROFICHE.

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE APR 94		3. REPORT TYPE AND DATES COVERED Final (4/01/93 - 5/01/94)
4. TITLE AND SUBTITLE Transport Aircraft Cockpit Program: An Evaluation of a Baseline Cockpit Configuration Promoting Crew Reduction in Tactical Transport Aircraft			5. FUNDING NUMBERS C F33615-93-D-3800 PE 62201 PR 2403 TA 04 WU SM	
6. AUTHOR(S) Eric J. Martin Joseph J. Cavallaro John A. Hassoun 1LT Thomas Conklin				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Veda, Incorporated 5200 Springfield Pike, Suite 200 Dayton, OH 45431-1255 USAF WPAFB / FIPC			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Flight Dynamics Directorate Wright Laboratory Air Force Materiel Command Wright-Patterson AFB, OH 45433 7562			10. SPONSORING/MONITORING AGENCY REPORT NUMBER WL-TR-95-3004	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION/AVAILABILITY STATEMENT APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED			12b. DISTRIBUTION CODE	
13. ABSTRACT (<i>Maximum 200 words</i>) The objective of the TRansport Aircraft Cockpit program (TRAC) is to develop, test and evaluate a mission-driven crew station design for tactical transport aircraft. This report details the first phase of this program: the evaluation of TRAC's functional baseline established for 1) primary flight, 2) communication and navigation, and 3) engine control and monitoring under two levels of task loading. This evaluation was conducted with 14 operational C-141 and C-130 pilots performing in two person crews, "flying" two simulated missions. Task-load was manipulated in an effort to expose any control and display deficiencies. Subjective workload was measured with the SWAT (Subjective Workload Assessment Technique) and SWORD (Subjective WORKload Dominance). SWAT ratings were collected to identify the mission segments with moderate to high workload. The SWORD technique was then employed to identify the control and display systems contributing to workload in those segments identified by SWAT. Finally, a systems questionnaire was administered to investigate the operability, intelligibility, effectiveness, and compatibility of each control and display. This report describes both the process of the TRAC evaluation as well as the evaluation results.				
14. SUBJECT TERMS tactical transport aircraft crew reduction workload			15. NUMBER OF PAGES 130	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL	

TABLE OF CONTENTS

LIST OF FIGURES	iv
LIST OF TABLES.....	iv
EXECUTIVE SUMMARY	1
INTRODUCTION	2
BACKGROUND	3
OBJECTIVES.....	3
METHODS.....	4
Subjects	4
Apparatus	4
Procedure.....	7
Training.....	7
Testing	8
Experimental Design	10
RESULTS AND DISCUSSION	11
SWAT	11
SWORD	12
QUESTIONNAIRES.....	17
CONCLUSION	19
REFERENCES	20
APPENDIX A -- TRAC SYSTEM DESCRIPTION	21
APPENDIX B -- TRAINING MATERIALS AND SYLLABUS	74
APPENDIX C -- STRATEGIC MISSION SCRIPTS	82
APPENDIX D -- SWORD DATA COLLECTION FORM.....	89
APPENDIX E -- SWORD ANOVAs	91
APPENDIX F -- QUESTIONNAIRE DATA: ACCEPTABILITY RATINGS AND COMMENTS	96

Accession For	
NTIS CRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution /	
Availability Codes	
Dist	Avail and/or Special
A-1	

LIST OF FIGURES

Transport Aircraft Cockpit (TRAC) Simulator	5
Mission 1 Scenario: Low Workload	9
Mission 2 Scenario: High Workload	9
Data Collection Strategy	11
SWAT Ratings by Mission by Segment	13
Mean SWORD Ratings for Each Mission Segment of Mission 1	14
Mean SWORD Ratings for Each Mission Segment of Mission 2	15

LIST OF TABLES

Subject Profiles	6
Typical TRAC Evaluation Schedule	8
Task Load Comparison	10

EXECUTIVE SUMMARY

The objective of the TRAnsport Aircraft Cockpit (TRAC) program is to develop, test, and evaluate a mission-driven crew station design for tactical transport aircraft that enables reductions in crew size. This report details the first phase of this program: the evaluation of TRAC's functional baseline established for (1) primary flight, (2) communication and navigation, and (3) aircraft systems (engine control and monitoring) operations.

The Strategic Demonstration and Evaluation was conducted in TRAC, a full mission simulator complete with a KC-135 aero-model, display dynamics, and full control capability. The simulator is a modified C-141 mockup which housed four large direct view Cathode Ray Tubes (CRTs) used to display the instrument panel and an out-the-window view. TRAC's flight control is provided by outboard, side mounted force sticks, one at each of the pilot and co-pilot stations, and four throttles mounted on a center pedestal.

This evaluation was conducted using 14 operational C-141 and C-130 pilots. Training was accomplished over 2 days. "Ground training" took place on the first day and consisted primarily of familiarization with the operation and interpretation of the controls and displays. The second training day was spent flying the simulator and exercising the control and display systems. Data collection was performed on the third (and in some cases, a fourth) day. In an effort to exercise the system and expose any control and display deficiencies, two missions were flown; one mission was flown under low task-load conditions and the other in relatively high task-load conditions. Workload was induced in the high task-load mission by disabling the Head-Up Display (HUD), flying the entire mission in Instrument Meteorological Conditions (IMC), and introducing two system failures during the mission: an engine failure shortly after departure and a flap failure on approach.

During both missions, subjective workload measures were collected using the Subjective Workload Assessment Technique (SWAT) and Subjective WORKload Dominance (SWORD). SWAT ratings were collected to identify the mission segments with moderate to high workload. The

SWORD technique was then employed to identify the control and display systems contributing to workload in those mission segments identified by SWAT. Finally, a control and display systems questionnaire was administered to investigate the intelligibility, compatibility, operability, and effectiveness of each control and display interface.

The SWAT analyses (Analysis of Variance, ANOVA) revealed a main effect of mission, a main effect of mission segment, and an interaction effect of mission and mission segment. This substantiated the task-load manipulation, and demonstrated that the cockpit controls and displays were employed under diverse conditions.

SWORD provided relative workload judgments and isolated the control and display subsystems contributing to workload. The SWORD analysis for mission one, the low task-load mission, revealed that the engine display used in this mission elicited more workload than the engine display in the crews' reference aircraft. For the high task-load mission, the SWORD analysis showed no difference between the TRAC control and display subsystems and those currently flown by the crews, supporting the assertion that the functional baseline established for TRAC's controls and displays was no worse than what is currently available. SWORD also revealed that for both TRAC and the crews' reference aircraft, the communication and navigation activities comprise the largest portion of total workload for strategic missions such as was simulated.

The subjective data above suggest that the engine display used in the low task-load mission as well as the communication and navigation controls and displays deserve redesign considerations. The questionnaire data supported this as well as highlighted possible improvements to other controls and displays. The questionnaires provided acceptability ratings for individual display components and each display as a whole. Subjects were also encouraged to comment on the control and display symbology. The acceptability ratings were plotted in frequency histograms and the comments cataloged by question number and subject. This analysis will provide the origin for the redesign process.

INTRODUCTION

The USAF Air Mobility Command (AMC) and Air Force Special Operations Command (AFSOC) have expressed the need for transport aircraft to perform missions on a global scale, day and night, in low to medium threat environments and in all weather conditions. Currently, AFSOC and AMC have a requirement for resupply missions into hostile or enemy controlled territory using airland and/or airdrop procedures. Additionally, Special Operations missions include infiltration, exfiltration, helicopter in-flight refueling, psychological operations, surface-to-air recovery, close air support, and aerial reconnaissance. Mission success often requires flight at altitudes of 200 feet or less at ground speeds between 220 and 260 knots, and under adverse weather conditions. These missions are further complicated by the need to reduce emissions to remain as clandestine as possible. To ensure continued success in these missions, improvements in navigation, sensor, flight control, and display technology are continuously sought by the user community. These improvements must be major elements of new tactical transport aircraft and will have a significant impact on crew station design.

Current tactical transport aircraft operations require four to five cockpit crew members to perform these various missions. The future need expressed by both AFSOC and AMC, however, is to successfully fly the same or more complex missions with a reduced crew size. To do this, mission requirements and emerging aircraft technologies for future tactical transport aircraft will be examined. The resulting level of automation provided in future vehicles must be sufficient to off-load the crew during peak workload periods in demanding sorties. Situation awareness for the remaining crew members will need to be equal to or greater than that experienced by crew members flying today's tactical transport missions. Despite automation, remaining crewmembers will still need to be aware of what functions are being automatically affected and when they occur. Additionally, manual tasking will need to be minimized and coordinated. Finally, mission essential information will need to be integrated and presented in a manner that does not compromise the crew members' capacity to process and disseminate the data.

The Transport Aircraft Cockpit (TRAC) program has been created to support current and future tactical transport cockpit development. The program

approach is to develop, design, and test new and emerging cockpit control and display interfaces to achieve the goal of crew reductions while increasing mission capability and effectiveness. This crew reduction is to be accomplished by enabling pilots through the full exploitation of avionics and sensor technology while maintaining acceptable levels of workload and situational awareness.

The process of developing crew system designs and design criteria permitting crew reductions is a structured process that begins with an analysis of requirements that the system is intended to meet. This activity, often referred to as mission analysis, is a fundamental part of the design development. By collating opinions, concepts, plans, technology assessments, and user statements of need, a coherent vision of the planned vehicle use, performance characteristics, functional capabilities, and design constraints can be developed. Details of the system design and operation can then be derived from this information. With respect to the crew station, the tasks that support this derivation process include the creation of mission profiles and timelines, function determination and allocation, and technology assessment. Next, a notional cockpit design can be actualized and implemented in a full-scale mock-up allowing role-playing through an entire mission scenario with a reduced crew. The effectiveness of the design can then be evaluated by operational tactical transport crew members flying simulated missions. Finally, the conceptual cockpit and its components can be subjected to multiple design iterations and trade studies to arrive at a functionally superior design permitting crew reductions and mission enhancement.

The purpose of the TRAC program is to perform both near and far term investigations of a variety of Special Operations Forces (SOF) and tactical transport crew station design concepts and produce simulation validated design criteria. The TRAC program plan employs a building block approach consisting of four phases: (1) Strategic Demonstration (2) Tactical Deployment (3) Tactical Ingress/Egress and (4) Full Mission Scenario. This report documents the first phase of this approach, the Strategic Demonstration and Evaluation. The design process outlined above will be accomplished in each of the four phases, resulting in the evolution of a conceptual cockpit to be evaluated in a Full Mission Scenario (Phase IV).

In the Strategic Demonstration and Evaluation phase, TRAC's functional baseline design was evaluated for (1) primary flight, (2) communication and navigation, and (3) engine control and monitoring using subjective techniques. That is, the first generation crew station control and display design formats were flown in a strategic (staging) mission for assessment purposes only. This demonstration marked the evaluation segment of the first design iteration. This subjective evaluation process identified control and display formats requiring modification, and will eventually result in a redesigned crew station. This modified crew station will be assessed in the Tactical Deployment Evaluation (Phase II) and the evaluation/redesign process continued. This report documents the Strategic Demonstration and Evaluation phase.

BACKGROUND

The feasibility of crew reductions and the impact on crew workload in Air Force transport operations has been a topic of interest in the last couple of decades. The availability of technologically advanced avionics as well as the desire to reduce costs have warranted such investigations. The focus of the TRAC program investigations is to accomplish these crew reductions without adversely affecting crew workload using advanced avionics and effective crew station designs. Subjective workload measures, therefore, are the cornerstone of the TRAC studies.

The feasibility of a KC-135 crew reduction was the subject of an Air Force study in 1976. Gieselhart, Schiffler, and Ivey (1976) conducted a series of flight tests with dual Inertial Navigation Systems, an advanced technology introduced at that time. They concluded that despite this cockpit upgrade, workload was still too excessive to allow the exclusion of the navigator.

More recent efforts have shown that including state-of-the-art avionics in the cockpit *would* accommodate a crew reduction without adversely affecting workload. In 1980, Barbato, Sexton, Moss, and Brandt determined the avionics control and display criteria needed to successfully accomplish the KC-135 mission. They used state-of-the-art systems available in the 1980's and concluded that a KC-135 crew reduction was possible provided the cockpit underwent a thorough redesign process. Following on this work, Madero, Barbato, and Moss (1981) developed a composite cockpit configuration that

was evaluated in a full mission simulation. Using the reconfigured cockpit, they concluded that the KC-135 mission could successfully be accomplished with a reduced crew (pilot, co-pilot, and boom operator; navigator eliminated) without having an adverse affect on crew workload. Similar crew reduction studies have been done for the C-141, C-5, and C-130 (Schiffler, Geiselhart, and Griffin, 1978).

Recently, Rueb, Barnaba, Hassoun, Dudley, and Ward (1992) revisited the KC-135 crew reduction/workload issue. In this study, Rueb et al. again investigated the feasibility of eliminating the navigator, reducing the crew size from four to three (pilot, co-pilot, and boom operator). Their results suggested that with proper crew systems controls and displays, this crew reduction could be achieved.

Of equal interest was the general approach taken by Rueb et al. to identify workload bottlenecks, isolate the contributing control and display interfaces, identify the problems with these interfaces, and remedy the control and display issues. Rueb et al. began their evaluation and redesign process with an assessment of crew workload. The assessment of workload has become a common part of the evaluation of new or redesigned pilot-vehicle interfaces (Gopher and Donchin, 1986; O'Donnell and Eggemeier, 1986). The reason workload assessment is an important consideration is that the human operator is adaptable enough to disguise the performance effects of demanding systems by expending additional effort. As a result, workload measures tend to be more sensitive to minor design deficiencies than performance measures, particularly in a mission context. Therefore, as in the Rueb et al. study, workload assessment was the focus of this current investigation, and critical evaluation and crew system redesign were subsequently employed in this effort.

OBJECTIVES

The primary objective of this effort was to evaluate TRAC's functional baseline established for (1) primary flight, (2) communication and navigation, and (3) aircraft systems (emphasizing engine control and monitoring) operations, under two levels of task-loading. In accomplishing the above objective, several secondary objectives were fulfilled:

1. The functionality and mechanization of the primary flight control and user display interface,

including the Electronic Attitude Direction Indicator (EADI), the Electronic Horizontal Situation Indicator (EHSI), and the Head-Up Display (HUD) were evaluated.

2. The functionality and mechanization of the communication and navigation control and user display interface, including the Communication/Navigation Control Panel (CNCN), the Control Display Unit (CDU), and the Horizontal Situation Format (HSF) were evaluated.
3. The functionality and mechanization of the aircraft systems user display interface, including the Automatic Flight Control System (AFCS), the Engine Status Format (ENG1), and the Engine Monitoring and Control Display (ENG2, or EMACS) were evaluated.

METHODS

Subjects

The test subjects all had operational flight experience and had been actively flying transport type aircraft (C-130 and C-141) within the last 24 months. To support the above objective, seven 2-person crews (14 subjects) participated in the evaluation, one crew per week, for a period of 7 weeks. The subjects had a wide range of experience and qualifications which are presented in Table 1. Three of the crews were C-141 pilots from the 356th Airlift Squadron (ALS), Wright-Patterson AFB, OH. Two C-130 crews were from AFSOC, Hurlburt Field, FL, representing the 8th and 15th Special Operations Squadrons, flying the MC-130E and MC-130H respectively. One C-130E crew was from Little Rock AFB and represented the 62nd ALS and the 50th ALS. Finally, one crew was comprised of two volunteers who responded to an advertisement for subjects. One of these volunteers was a C-141 pilot from the 907th Airlift Group; the other was a Navy P-3 pilot currently assigned to the Joint Primary Aircraft Training System (JPATS) office. The crew members mean total flight hours was 2762 with a standard deviation of 1190 hours. None of the crews were "hard crews"; that is, although the pilots of a given TRAC evaluation crew may have flown

together in the past, they were not assigned by their squadron to fly with one another exclusively.

Apparatus

The evaluation was conducted in TRAC, a full mission simulator complete with a KC-135 aeromodel, display dynamics, and full control capability. TRAC allowed the subjects to "fly" a realistic mission, providing a platform from which various human factors issues could be studied. The cockpit shell was a modified C-141 mockup which was altered to accommodate control and display reconfigurations required for the conduct of the Strategic Evaluation (Figure 1). The instrument panel was displayed using three 21-inch Mitsubishi color display monitors, allowing a variety of display configurations from different aircraft designs to be presented and evaluated. One 16-inch color display monitor furnished the pilot's out-the-window view as well as the Head-Up Display (HUD). The displays were driven by four Silicon Graphics Display Generators, with the instrument panel controls provided by capacitance sensitive touch panels and electromechanical switches. The control inputs were accomplished using outboard, side-mounted force sticks, one at each pilot station, and a multi-engine throttle set, located on the center pedestal. Two Control Display Units (CDUs) mounted on the center pedestal provided each pilot with full mission management capability. Finally, the Automatic Flight Control System (AFCS) and two Communication/Navigation Control Panels (CNCNs), one for each crew station, were mounted above the instrument panel on the glareshield.

The aeromodel as well as the throttle and stick inputs were updated at a rate of 30 Hz. The cockpit displays were updated at a rate of 10-15 Hz, depending on the complexity of the display set being generated. The three 21-inch color display monitors were used to display the four available formats: 1) Primary Flight Format (PFF, consisting of EADI and EHSI), 2) Horizontal Situation Format (HSF), 3) an Engine Format (ENG1 or ENG2), and 4) Checklists. The formats are described in Appendix A. Each monitor displayed any two of the above formats. The three monitors were mounted across the instrument panel with one in front of each the pilots and the third

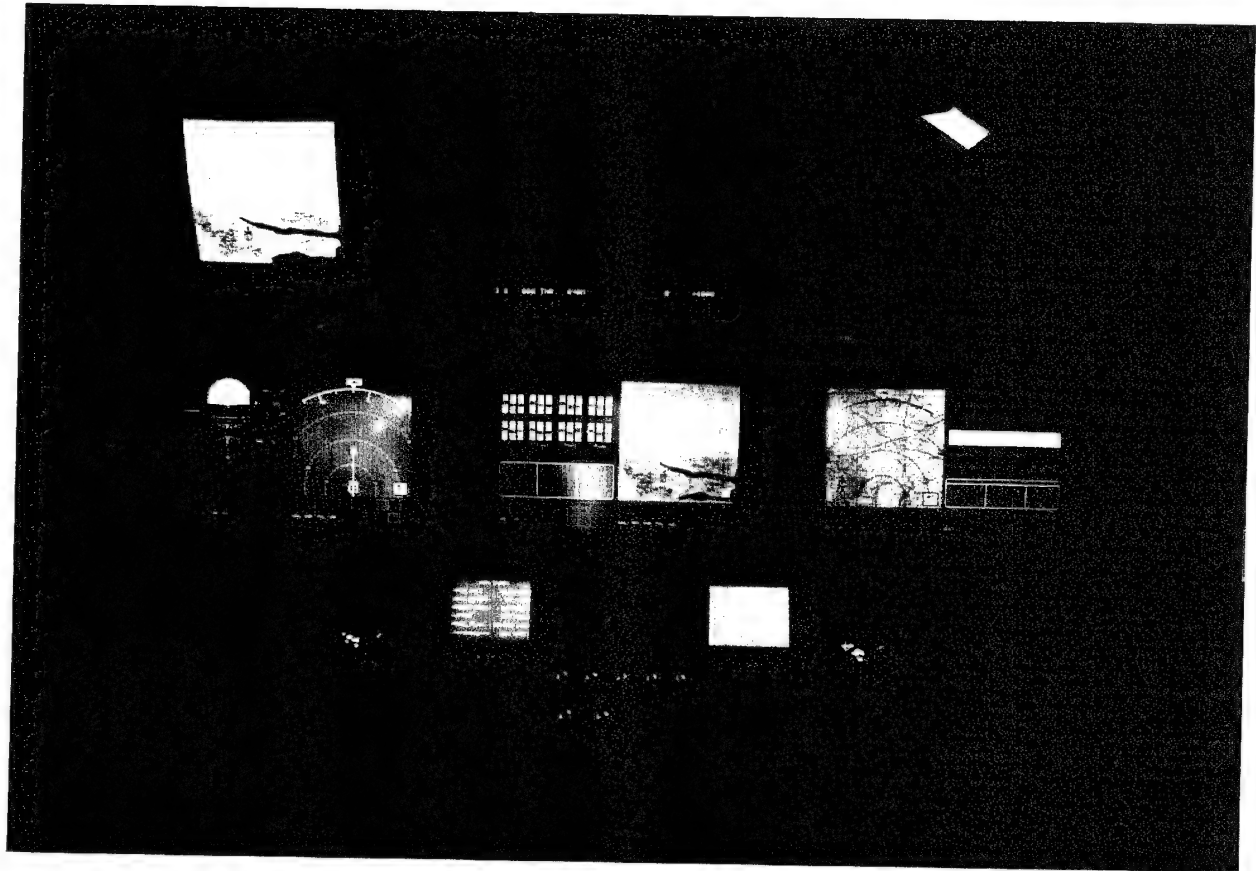


Figure 1. Transport Aircraft Cockpit (TRAC) Simulator.

Table 1. Subject Profiles. Aero Ratings: IP Instructor Pilot, FP First Pilot, AC Aircraft Commander, EP Evaluator Pilot, CP Co-Pilot. Special Qualifications: LL Low Level, IFR In-Flight Refueling, NVG Night Vision Goggles, SOLL Special Operations Low Level, SKE Station Keeping, LAPES Low Altitude Parachute Extraction, TF/TA Terrain Following/Terrain Avoidance.

Subject No.	Grade	Age	Handed-ness	Aero Rating	Total Hours	Primary Aircraft	Crew Position	Special Qualifications
1	CPT	34	R	IP	4950	C-141	P	Airdrop, LL, IFR
2	1LT	31	R	FP	1800	C-141	CP	None
3	CPT	34	R	IP	2500	C-141	P	IFR, NVG, SOLL I & II, Formation
4	CPT	31	L	IP	3580	C-141	CP	IFR
5	CPT	31	R	AC	3460	C-141	P	IFR
6	CPT	29	R	AC	2375	C-141	CP	None
7	CMDR	39	R	EP	5180	P-3	P	Formation
8	MAJ	33	R	IP	2150	C-141	CP	Airdrop, SKE, Formation
9	CPT	31	L	EP	2975	C-130E	P	Airdrop, SKE, Formation, SOLL
10	CPT	26	R	CP	800	C-130E	CP	Airdrop, SKE, NVG, LAPES, Formation
11	CPT	29	R	AC	2300	MC-130E	P	Airdrop, IFR, TF/TA, NVG, Formation, Helo Refuel
12	CPT	32	R	AC	3000	MC-130E	CP	Airdrop, IFR, TF/TA, NVG, Formation,
13	CPT	28	R	CP	1300	MC-130H	P	Airdrop, IFR, NVG, TF/TA, SKE, Formation
14	CPT	29	R	AC	2300	MC-130H	CP	Airdrop, IFR, NVG, LAPES, TF/TA, SKE, Formation

centered between them. In every case, the pilots selected the PFF as one of the two formats displayed in front of them, using the second available position for either the HSF or an Engine Format. The center monitor often was used to display a Checklist page and either the HSF or an Engine Format. The crews were permitted to interchange formats throughout the mission. A detailed description of each of the control and display formats is provided in Appendix A.

The crews were permitted to arrange the displays according to their preference, with one exception. For the purpose of evaluation, two engine control and monitoring displays were available. In the low task-loading mission, Mission Scenario One, the crews were asked to "fly" with the Engine Monitoring and Control System (EMACS, referred to as ENG2 throughout this paper), developed by NASA. The other engine display, a C-130 Reliability and Maintainability Technology Insertion Program (RAMTIP) derivative was flown in Mission Scenario Two, the high task-loading mission.

Procedure

Each two-person crew was involved in 2 days of training and 1 day of data collection. A typical daily schedule for the crews is shown in Table 2.

Training. Training consisted of 5 hours of ground training and 6 hours of simulator flight training. All of the training materials including the training syllabus are provided in Appendix B. The ground training was divided into three 1-hour sessions and one 2-hour session. The first session covered administrative items such as program briefing, facilities familiarization, and safety considerations. The second session consisted of cockpit familiarization, confined specifically to cockpit layout and functionality. In the third ground training session, the subjects received instruction on control and display operations, to include symbology formats and functionality. Finally, in the fourth and final ground training session, the crew actively participated in a "hands on" control and display exercise. In this exercise, the crews selected and manipulated the various displays and display options available on the touch sensitive CRTs. The crews entered, changed, and deselected navigation

frequencies and courses as well as communication channels on the Communication/Navigation Control Panel (CNCP). They performed all the available functions of the Automatic Flight Control System (AFCS) including setting altitude and airspeed reference markers, and engaging and setting the Autopilot parameters. Finally, the crews performed all available flight plan manipulations on the Control Display Unit (CDU), including adding, deleting, and changing waypoints as well as inputting radial and Distance Measuring Equipment (DME) fixes. The operating instructions for each control and display are provided in Appendix B. The simulator flight training involved two sessions. Each session was 3 hours in duration, with each subject serving as the pilot for one and a half hours of each session. The first of these was a simulator familiarization flight and included basic flight maneuvers (i.e., climbs, descents, and airspeed changes). The second simulator flight training session consisted of specific instrument procedure maneuvers (i.e., holding, instrument approaches, etc.) as well as multiple landings.

Before each of the two flight training sessions, the subjects received instructions regarding the reporting of Subjective Workload Assessment Technique (SWAT) ratings, described in the Data Collection section below (see Appendix C for SWAT directions). During the simulator flight training, they were asked to report their SWAT scores for practice and familiarization with the technique.

An experimenter directed and observed the training program of each crew and evaluated their performance in the last flight training session. The subjects were deemed fit to proceed into the evaluation phase by the experimenter when they could maintain heading (± 10 degrees), altitude (± 100 feet), and airspeed (± 10 knots) while operating the other aircraft control and display systems for the duration of the flight training session. These criteria were obtained from the C-141 Pilot Requalification Course - Flight Pilot Guide, Hughes Training, Inc. The schedule of ground and flight training proved adequate in developing sufficient proficiency in control of the simulator such that the data collected in the strategic demonstration was useful in evaluating the design of the TRAC cockpit.

Table 2. Typical TRAC Evaluation Schedule. This schedule was adjusted when necessary to accommodate the crews, with the progression of events remaining undisturbed

	MONDAY	TUESDAY	WED	THURS
0800	FIP Brief and Tour	Flt Trng Brief	Data 1 Brief	Back-up
0900	Ground Trng 1	Flt Trng Session 1	Data Session 1	Back-up
1000	Ground Trng 2	Flt Trng Session 1	Data Session 1	Back-up
1100	Ground Trng 3	Flt Trng Session 1	Debrief	Back-up
1200	Lunch	Lunch	Lunch	Lunch
1300	Ground Trng 4	Flt Trng Brief	Data 2 Brief	Back-up
1400	Ground Trng 4	Flt Trng Session 2	Data Session 2	Back-up
1500	Off	Flt Trng Session 2	Data Session 2	Back-up
1600	Off	Flt Trng Session 2	Debrief	Back-up

Testing. After sufficient training, the two-person crew was asked to "fly" two simulated mission scenarios. Each of the mission scenarios was designed to represent a typical round robin training mission originating from Pope AFB. Both mission sequences began with a routine departure and proceeded through cruise, reroute, cruise, and descent segments, ending with an instrument approach and landing. The mission scenarios are represented in Figure 2 (Mission Scenario One) and Figure 3 (Mission Scenario Two). The scenarios were programmed for one and one-half hours of flight time over six route legs. Each scenario was designed to incorporate multiple radio calls and frequency changes, an airborne reroute, and an approach to a full stop landing. One mission was performed under low task-loading conditions while the other was flown with high task-loading. For the low task-loading condition, the crews were provided with 1 hour of premission planning time, flew in Visual Meteorological Conditions (VMC), and experienced no system malfunctions during the course of the mission. During the high task-loading condition, the crews departed without the benefit of premission planning, conducted the mission without the use of a Head-Up Display (HUD), flew in Instrument Meteorological Conditions (IMC) below ILS minimum weather criteria, and experienced two aircraft systems malfunctions during critical phases of flight. Table 3 summarizes the differences between the low task-load mission and the high task-load mission.

Each crew conducted these simulated missions in TRAC according to formal mission scripts (Appendix D). The scripts were used to simulate communication with control centers and provided mission commonality across the crews. The scripts also were used to promote activity with several control and display interfaces.

The task-load manipulation was introduced with the intent of exercising the TRAC system under demanding conditions to exhibit TRAC's design relevance and versatility as well as to expose its deficiencies. Control and display deficiencies that might not be exposed during routine operation, could be revealed when time availability is critically low, and mental effort and psychological stress are high. In an effort to reduce a potential training effect resulting from using the exact mission scenario for each of the task-load conditions, two mission scenarios were used. The scenarios were fundamentally the same with respect to the primary flight objectives and level of communication and navigation activities. Both mission scenarios had the same number of route legs, radio calls, and flight plan manipulations resulting from a reroute. Recall from Figure 2 and Figure 3 that the only difference between the mission scenarios was with respect to the route flown. The order in which these mission scenarios were flown was counterbalanced across crews. Four crews flew the Mission Scenario One first, followed by Mission Scenario Two.

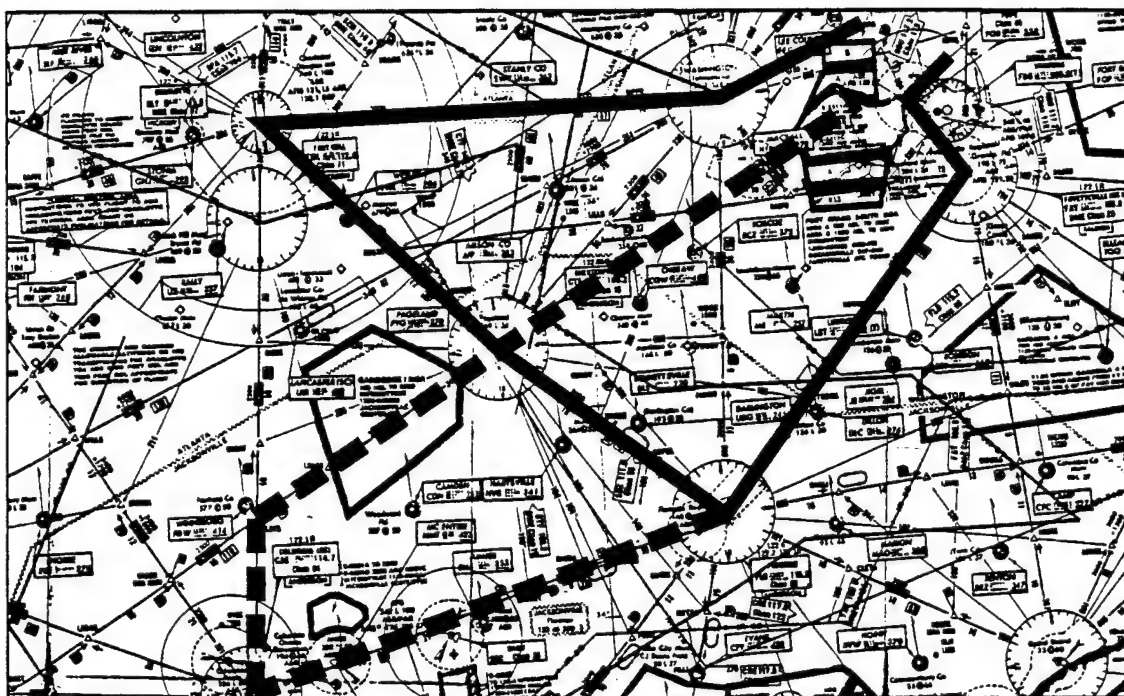


Figure 2. Mission Scenario One. Low Task-load — Original Route — Amended Route

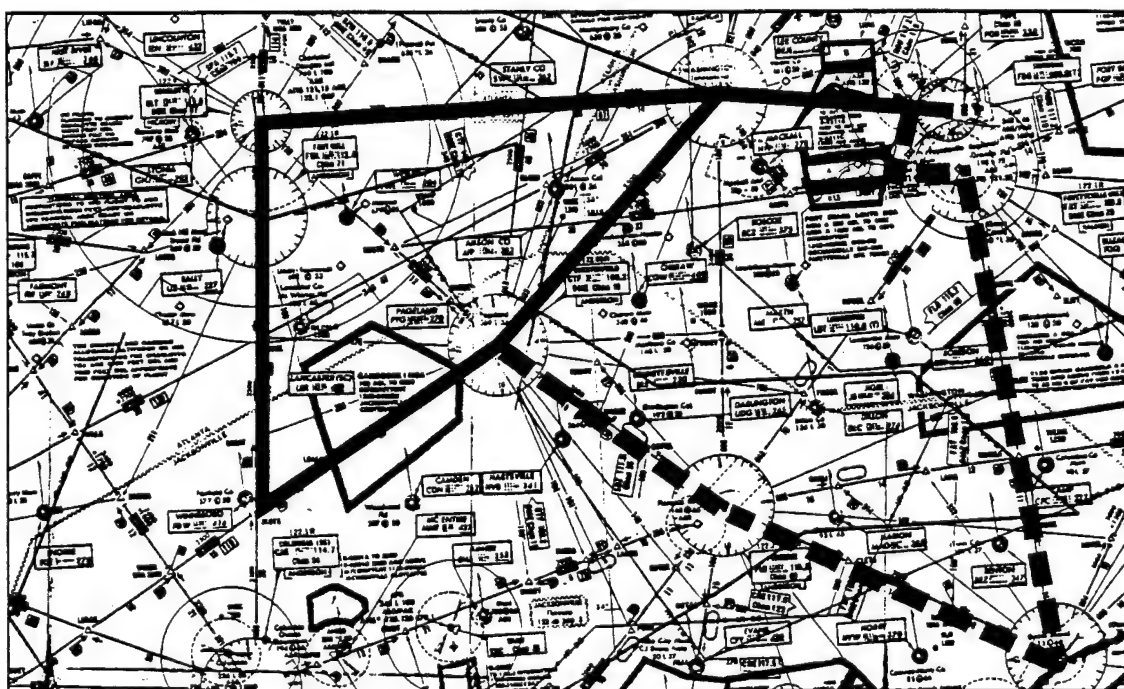


Figure 3. Mission Scenario Two. Low Task-load. — Original Route — Amended Route

Table 3. Task-load Comparison

Low Task-load	High Task-load
1 Hour provided for predeparture route study; cockpit setup accomplished prior to takeoff.	No time provided for predeparture route study; cockpit setup accomplished enroute.
All systems available and operating normally.	All systems, except HUD, available.
No system malfunctions introduced.	Engine failure (critical engine) introduced shortly after takeoff. Flap failure introduced shortly before landing.
Entire mission flown in Visual Meteorological Conditions.	Entire mission flown in Instrument Meteorological Conditions, below ILS approach minimums. On final approach WX conditions set to ILS, visibility only, approach minimums.

Experimental Design

A repeated measures design was employed in this study. Through counterbalancing, four crews flew the low task-loading mission first (Mission Scenario One), followed by the high task-loading mission (Mission Scenario Two). The other three crews experienced the reverse situation.

The data collected for the TRAC evaluation consisted of subjective measures exclusively. The subjective measures included Subjective Workload Assessment Technique (SWAT) ratings, Subjective Workload Dominance (SWORD) comparisons (a sample form is shown in Appendix E), and pilot commentary on a series of post-session questionnaires (questionnaires shown in Appendix F). Figure 4 provides an overview of the data collection strategy.

The SWAT technique was used to collect a composite measure of workload based on three factors: the relative levels of time load, mental effort, and psychological stress experienced by each crew member. Time Load depends on the availability of spare time and the overlap of task activities. Mental effort reflects the amount of attention or concentration that is required to accomplish a task,

independent of the number of subtasks or time limitations. Psychological stress refers to conditions that produce confusion, frustration, and/or anxiety during task performance and, therefore, make task accomplishment seem more difficult. A more extensive discussion of SWAT is found in Reid, et al., (1989). In both the high and low task-load missions, SWAT data were collected for each of the following segments: (1) departure, (2) cruise 1, (3) reroute, (4) cruise 2, (5) descent, and (6) ILS approach and landing. SWAT identified those mission segments with relatively high levels of workload. SWAT reflected the success of this task-load manipulation. From the standpoint of crew reduction, SWAT could also indicate if accomplishing the Strategic Demonstration and Evaluation missions with a two-person crew would result in unmanageable levels of workload.

The SWORD procedure was employed at the completion of each data collection session. SWORD allowed a workload comparison between TRAC and the pilots' baseline cockpit for primary flight, communication and navigation, and aircraft systems operations. A more extensive discussion of SWORD can be found in Vidulich (1989). The reference aircraft differed (e.g., C-130 and C-141); however, the functions of interest were fundamentally the same and restricting the investigation to one airframe

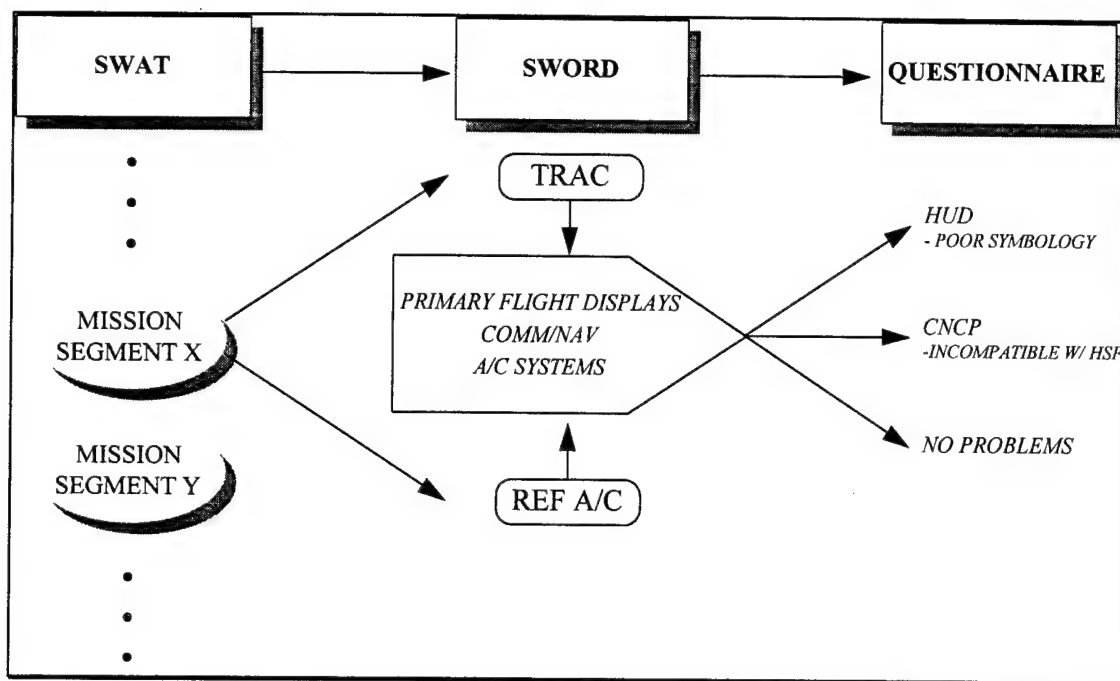


Figure 4. A graphical description of the subjective data collection strategy. SWAT identified the mission segments with relatively high levels of workload. This led to an investigation of that segment using SWORD, which identified which control and display systems were contributing to workload. Finally, the questionnaires identified what was difficult about operating those control and display systems.

would have increased the difficulty of recruiting subjects as well as limiting the scope of the study. SWORD was collected from each crew member for each of the six mission segments. Those segments identified by SWAT as having relatively high levels of workload were further investigated using SWORD. SWORD identified the control and display systems requiring a more thorough review. An unstructured interview process was used to support SWORD data collection.

A set of detailed control and display systems questionnaires, administered at the conclusion of the last evaluation period, was used to isolate any display formats producing complications, and expose what was difficult about operating them (the questionnaire set may be found in Appendix F). These questionnaires investigated the intelligibility, compatibility, operability, and effectiveness of each system. Three questionnaires were administered to both crew members; one for each of the nine format controls and displays pertaining to primary flight (EADI, EHSI, HUD), communication and navigation (CNCP, CDU, HSF), and aircraft systems (ENG1, ENG2, AFCS). Included in the questionnaire set

were a set of questions addressing the general TRAC systems; the side mounted force stick and the capacitance touch sensitive panels, in particular. A biographical survey was also included in the questionnaire set, providing the subject's grade, age, sex, aeronautical rating, duty organization and station, and flight hours for each airframe flown. These data were cataloged for administrative purposes and also used during the analyses to investigate potential differences among the crews. Finally, a TRAC program critique was included in the questionnaire set to solicit comments regarding the evaluation process itself, the facility, and the experimenters.

RESULTS AND DISCUSSION

SWAT

SWAT ratings were averaged across subjects and plotted sequentially for both missions for each of the six mission segments (departure, cruise 1, reroute, cruise 2, descent, and ILS approach and landing) to isolate those mission segments with relatively high

workload (see Figure 5). A SWAT rating of 40 (on a scale of 0-100) was used as the threshold for identifying mission segments containing high workload. This value has proven to be sufficiently sensitive to workload variation, as evident in reports from similar work (Rueb, et al. 1992; Cone and Hassoun, 1992; Reid and Colle, 1988). Reid and Colle (1988) refer to the region near 40 on the SWAT scale as a "red zone," cautioning that workload much above this begins to have a detrimental affect on performance. There were no Mission 1 segments identified as having high workload, however, three Mission 2 segments; cruise 1, reroute, and approach/land, registered high workload. A repeated measures Analysis of Variance (ANOVA) was used to identify a difference in workload for each mission across mission segments. A one-way repeated measures ANOVA revealed a main effect of mission ($F(1,13) = 15.02, p < .05$). A similar analysis exposed a main effect of mission segment ($F(5,65) = 10.85, p < .05$). The interaction of mission and mission segment, examined with a 2 x 6 repeated measures ANOVA, also produced a significant effect ($F(5,65) = 3.17, p < .05$). The remaining analyses have particular utility with respect to those segments identified as having relatively high workload.

The results of the SWAT data analysis exposed the intended effect of the workload manipulation: to induce workload across and within the missions to exhibit TRAC's design relevance and versatility as well as to expose its deficiencies. Using a SWAT rating of 40 to establish a threshold for high workload, it can be seen that no Mission 1 segments qualified as such. This would indicate that for an "easy" mission such as Mission 1, workload remained manageable given the baseline TRAC cockpit design. For Mission 2, however, three segments were identified as containing high workload: cruise 1, reroute, and approach/land. It is these mission segments that will be given increased attention in the ensuing analyses.

Regarding the significant difference between the missions, recall that Mission 2, the high workload mission, was initiated without the benefit of pre-mission planning time, flown without the HUD, and flown in IMC. After establishing the first waypoint, the crew was pressed to get airborne. The result of this was that mission planning, accomplished with the mission computer (the Control Display Unit, or CDU) and the CNCP, was executed during departure and during much of the first cruise segment of the

mission. Having nearly completed the mission planning, the crew was then given the reroute. This immediate and persistent mission planning activity is probably responsible for driving the workload of the reroute phase into the high workload region (greater than 40 on the SWAT scale). Additionally, the first system malfunction, a "flame-out" of Engine 1, was imposed during climb-out, shortly after the crew had established an intermediate level-off altitude. These influences clearly had an effect on crew workload during the first cruise and reroute segments of the high workload mission. Similarly, the reduced visibility and flap failure are likely responsible for the high workload found in the approach/landing segment of the high workload mission.

Of interest was the post hoc discovery that there was no significant difference in the SWAT scores between crew members ($F(1,13) = 0.92, p > .05$); that is, the pilot and co-pilot appeared to distribute the workload evenly amongst themselves. This not only exhibited the high degree of crew coordination practiced by the subjects, but also allowed the SWAT scores of both pilots and co-pilots to be pooled for the analyses. Post hoc analysis also showed no significant difference in the reporting of SWAT scores as a function of the crews' reference aircraft ($F(5,161) = 0.76, p > .05$). This was investigated when a graph of SWAT scores indicated that the C-141 pilots responded with noticeably higher SWAT scores in the high workload mission.

SWORD

The SWORD (Subjective Workload Dominance) procedure provided a comparison of TRAC to the pilots' reference aircraft regarding the relative functionality of the control and display systems (primary flight, communication and navigation, and aircraft systems). The SWORD technique uses a series of relative judgments to accomplish this comparison. This comparison provides an indication as to whether TRAC is similar to the reference aircraft in terms of the workload associated with its operation. Additionally, SWORD furnishes information with regards to the control and display system(s) contributing to the workload. SWORD was collected after each mission from each crew member for each mission segment. The resulting ratings were combined for all subjects and a mean rating was calculated. (These mean ratings are presented in Figure 6 (Mission 1) and Figure 7 (Mission 2), with one graph for each mission

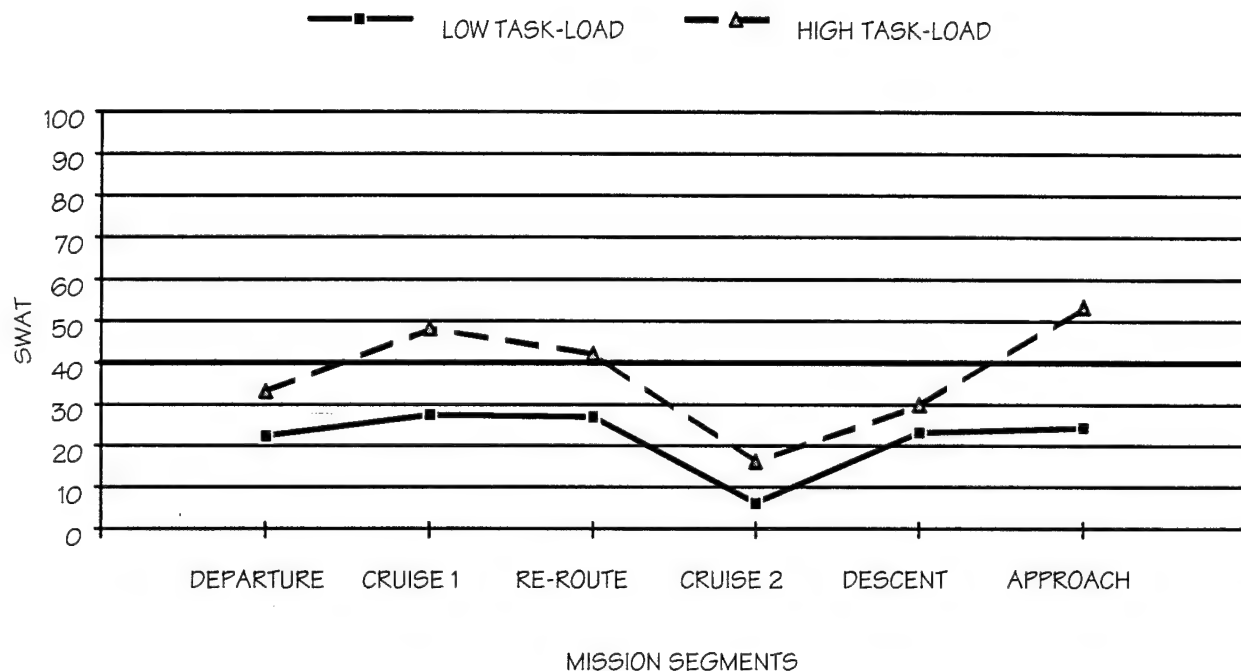


Figure 5. SWAT ratings by mission and segment.

segment.) A separate two-by-three repeated measures ANOVA was performed for each mission segment of each mission, resulting in a total of 12 individual analyses. The results of these analyses can be found in Appendix G.

An inspection of the Mission 1 data (Figure 6) reveals no consistent pattern of results with regards to statistically significant findings. What is consistent, however, is the relatively high registration of TRAC's aircraft systems displays. They repeatedly resulted in higher workload than those of the reference aircraft. Recall that for the purpose of evaluation, the EMACS (Engine Monitoring and Control System) engine display was flown for this mission. Based on crew commentary, this engine control and monitoring display clearly elicited more workload than that of the reference aircraft. The difficulties encountered with this display will be discussed in a following section of this report. It should be noted, however, that the EMACS display was not implemented in its entirety. While the engine monitoring components of this display were well represented, the complement control components were not. This incomplete representation of the EMACS display surely contributed to the unfavorable reaction it received. The EMACS display will be restored and re-

evaluated in the Tactical Deployment Demonstration (Phase II).

For Mission 2 (Figure 7), a couple of findings should be noted. First, the SWORD graphs reveal that TRAC and its control and display systems (primary flight, communication/navigation, and aircraft systems, or, ENG1) were, at least, no worse than the reference aircraft in terms of eliciting workload. This is a significant finding in that it substantiates TRAC's current configuration as a functional baseline for primary flight, communication and navigation, and aircraft systems operations. The second notable finding is the main effect of control and display systems (primary flight, communication/navigation, and aircraft systems). The communication and navigation controls and displays elicited more workload than either primary flight or engine control and monitoring, as would be expected in a strategic mission such as those that were flown in the evaluation. Additionally, this variation is similar to that experienced by the crews in their reference aircraft, again establishing the current TRAC configuration as a functional baseline.

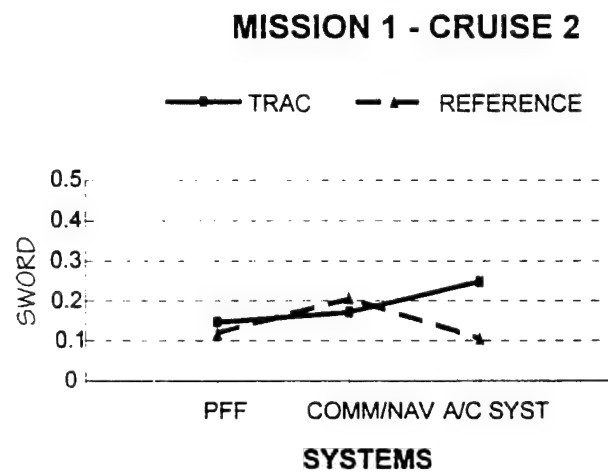
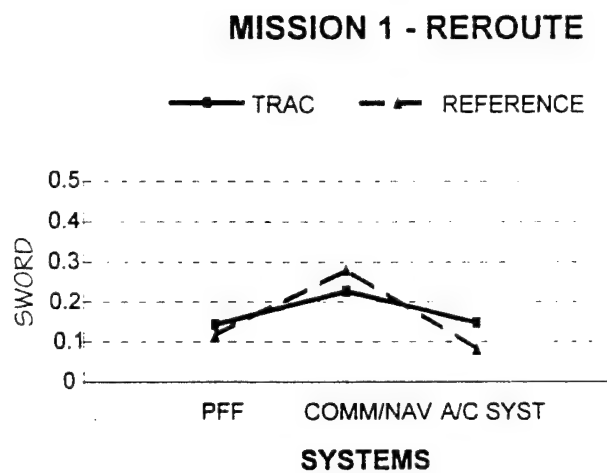
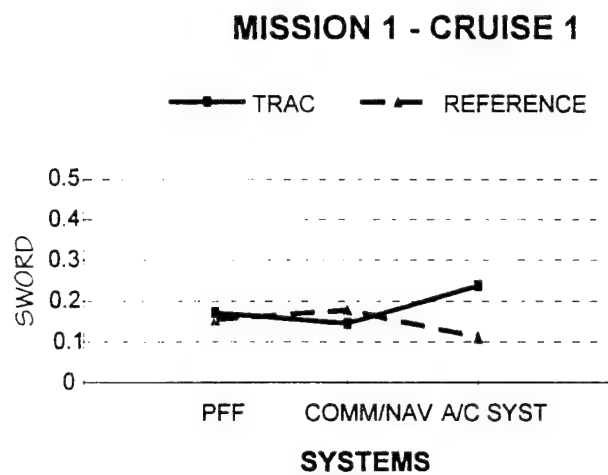
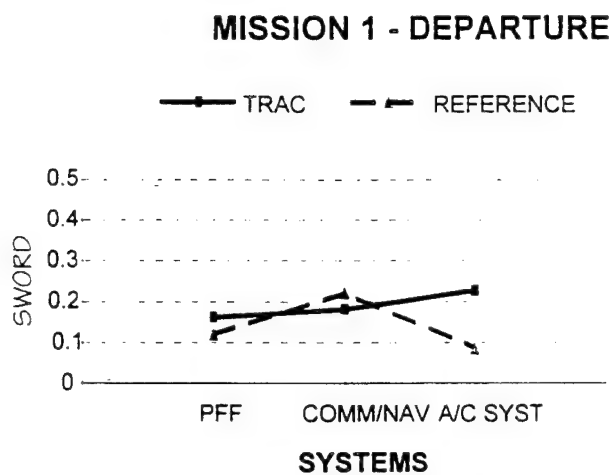
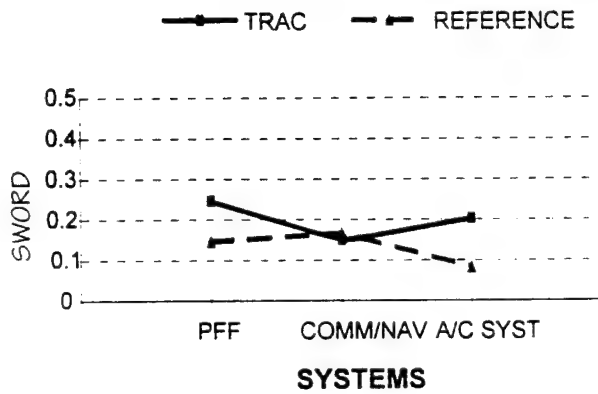


Figure 6. Mean SWORD ratings for each mission segment of Mission 1.

MISSION 1 - DESCENT



MISSION 1 - APP/LANDING

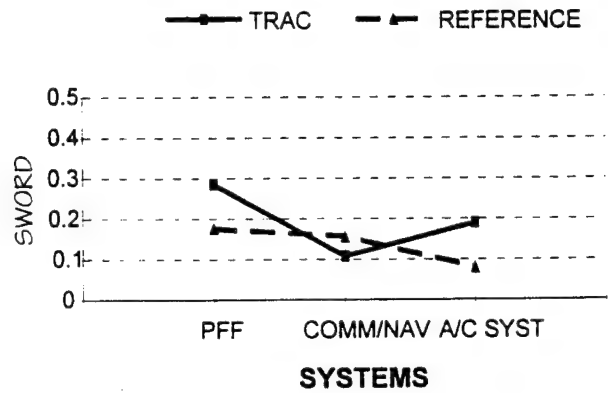
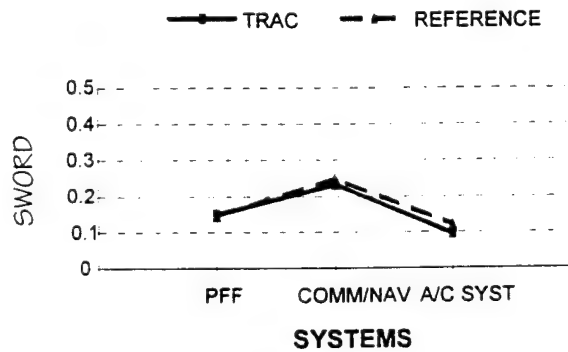


Figure 6. Continued.

MISSION 2 - DEPARTURE



MISSION 2 -- CRUISE 1

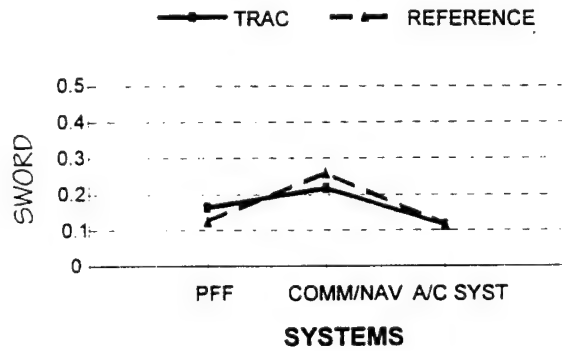


Figure 7. Mean SWORD ratings for each mission segment of Mission 2.

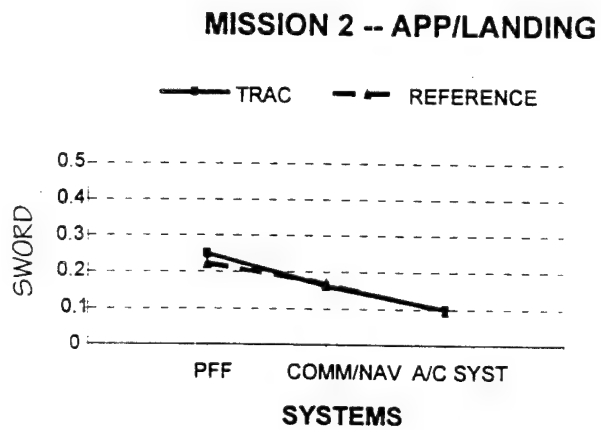
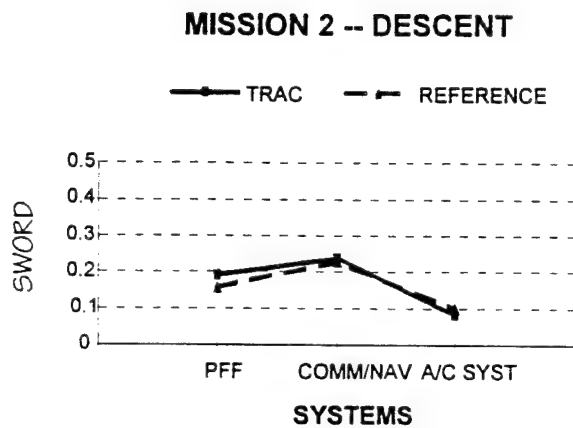
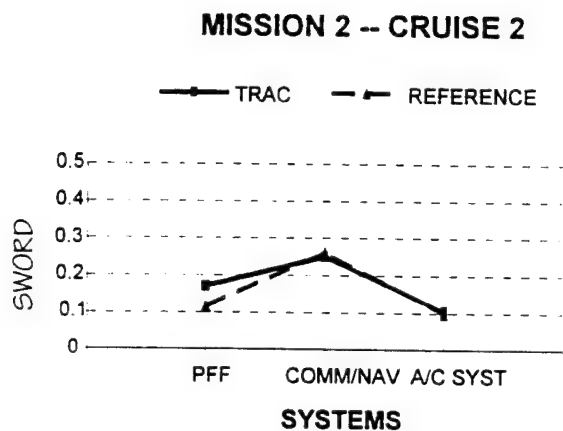
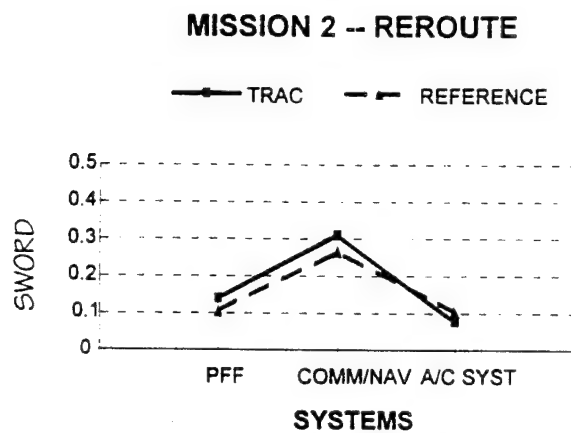


Figure 7. Continued.

QUESTIONNAIRES

A set of questionnaires was administered to the subjects upon completion of the second mission. These questionnaires focused on the intelligibility, compatibility, operability, and effectiveness of each of the control and display system formats and identified the deficiencies associated with them. The control and display systems questionnaire provided two types of data: acceptability ratings and subjective comments. Subjects provided acceptability ratings on each element of each control/display interface as well as on the control/display as a whole, providing a quantitative measure of approval. The ratings collected on the control/display elements focused on such issues as size, color, and contrast as well as interpretability and meaningfulness of the symbology. A copy of the original questionnaire is provided in Appendix F. Frequency histograms were constructed from these data to determine the unfavorable characteristics of each control and display format, but no formal statistical analyses beyond this were accomplished. Additionally, the subjects were encouraged to provide comments on both the elements of each display format and the display as a whole. Both the acceptability ratings and all of the subjective comments were assembled and cataloged by display providing an origin for the ensuing redesign process. This inventory of acceptability ratings and comments can be found in Appendix H.

Generally speaking, the current control and display formats were very well received. That is not to say that the baseline configuration cannot be improved. Several items repeatedly received negative commentary from the crew members. Other issues, though significant in nature, were identified by only a few, and in some cases, only one crew member. For the sake of brevity, the following discussion will concentrate on those issues that were consistently identified by the crews as being possibly problematic. The less reported issues can be found in the inventory provided in Appendix H. Regardless of the frequency with which the various comments were received, each and every comment provided by the crews will be considered during the redesign process.

Regarding the Electronic Attitude Director Indicator (EADI, shown in Figure A-2 of Appendix A), a number of subjects recommended enlarging the climb/dive ladder and expanding the scale. Two

pilots suggested enlarging the entire EADI display unit. Nearly half of the subjects proposed incrementing the altimeter tape in units of 10 feet, rather than 1 foot. In addition, several crew members noticed that the commanded altitude marker would become obscured when the commanded altitude was achieved. Nearly universal among the crews was the opinion that the Vertical Velocity Indicator was too small and hard to read. In addition, both the scale and the tape were white, contributing to a lack of contrast. Some new EADI symbology was introduced in accordance with a head down display standardization program: a "speed worm," an acceleration cue, a climb/dive marker, and a flight path marker. These were often removed from the display with the declutter option. Some pilots commented they would require more experience and practice with the new symbology before feeling comfortable enough to fly with it exclusively. A criticism received from nearly every crew member was that the multitude of options that could be simultaneously displayed could result in pilot-induced clutter. Overall, however, the EADI was determined to be at least moderately acceptable by 12 of the 14 subjects.

The crew members made only a few recommendations for the Electronic Horizontal Situation Indicator (EHSI, shown in Figure A-2 of Appendix A). Due to the ability to display multiple navigation aids on TRAC's EHSI, a number of the crews mentioned that the primary navigation bearing pointer should be displayed at all times. When displaying more than one navigation aid, many of the crews suggested that the information normally displayed with a navigation aid (the station identifier, frequency, and Distance Measuring Equipment (DME)) should be displayed for secondary navigation aids as well. The crews also mentioned that there is quite a lot of similar symbology that needs to be differentiated. These issues were apparently considered as minor, as 12 of the 14 crew members rated the EHSI as "moderately acceptable" or better. Due to an implementation limitation, the Head Up Display (HUD, shown in Figure A-1 of Appendix A) received a poor review by the crew members. An actual HUD mechanism was not available, so the HUD symbology was super-imposed on the out-the-window display monitor. In keeping with HUD standardization specifications for symbology size, the HUD symbology size was not adjusted accordingly. This resulted in the HUD symbology being far too small. In addition, super-imposing the HUD display on the out-the-window display resulted in a loss of contrast between the

HUD symbology and the viewing background. Most of the comments collected from the crew members were about these size and contrast problems with the symbology. Half of the subjects considered the HUD to be "borderline" or worse.

The Horizontal Situation Format (HSF, shown in Figure A-3 of Appendix A) received the most positive response of all the displays. Nine subjects reported that the display was "very acceptable," the highest rating available. Thirteen of the 14 subjects rated the HSF as "moderately acceptable" or better. Some recommended improvements include increasing the available range up to 300 NM and providing "trend dots." Trend dots provide the pilots with a predicted position of the aircraft at 10, 20, and 30 seconds in the future, as a function of current aircraft vector and velocity. These are currently used in some Special Operations aircraft (MC-130H) and have proven particularly useful in low level operations.

Regarding the Communication/Navigation Control Panel (CNCP, shown in Figure A-11 of Appendix A), 11 of the 14 subjects found the unit to be "moderately acceptable" or better. Three subjects rated the CNCP as "borderline." Two comments routinely surfaced with respect to the CNCP; it was difficult to monitor the other pilot's CNCP activity, and it blocked too much outside visibility. In addition, the pilots thought that providing a method to make selections on the other pilot's CNCP would be very useful.

The crews also made a few suggestions for improving the Control Display Unit (CDU, shown in Figure A-15 of Appendix A). Repositioning or reorienting them with respect to the crew member would increase display readability as well as reduce the potential for parallax distortion. As with the CNCP, the crews would also like to be able to monitor each others display. Generally speaking, however, 12 subjects regarded the CDU as "moderately acceptable" or "very acceptable."

The Engine Status Format (ENG1, shown in Figure A-5 of Appendix A) was deemed "moderately acceptable" by half of the crew members. Three crew members rated it as "very acceptable" while four thought it was "borderline." The most frequently received comment on the ENG1 display was that each of the engine parameter tape scales need to be expanded in the operating range to improve readability. In their current form, many of

the scales include regions where engine operation is either impossible or meaningless. These regions could be eliminated allowing the operating range to be expanded. Four of the subjects felt that the Automatic Caution and Warning System (ACAWS) was not prominent enough and that the messages displayed there needed to be clearer. Finally, a few crew members recommended highlighting the particular control parameter tape set that is being used to set power, making it easier to distinguish from the other tapes.

The Engine Monitoring and Control System (EMACS, shown in Figure A-6 of Appendix A) fared very poorly in the evaluation. Recall, however, that the EMACS display was not implemented in its entirety. While the engine monitoring components of this display were well represented, the complement control components were not. This incomplete representation of the EMACS display surely contributed to the unfavorable reaction it received. All 14 subjects rated the EMACS engine display as "borderline" or worse, with six subjects identifying the display as "very unacceptable." With just the engine monitoring component of this display operational, it was very difficult for the crews to accurately affect power changes. However, three subjects had a positive comment on the EMACS display; the method for displaying an engine malfunction or warning was immediately noticeable and clear. The EMACS display will be corrected and reevaluated during the second phase of the TRAC program.

Regarding the Automatic Flight Control System (AFCS, shown in Figure A-14 of Appendix A), nine of the 14 subjects identified it as "moderately acceptable" or better. Four of the crew members rated the AFCS as "borderline" and one considered it "moderately unacceptable." Several of the subjects thought that it was larger than it needed to be and that it was too large, blocking too much of the outside view. A number of subjects also thought that there were too many buttons and knobs, many of which were not operational or inappropriately presented.

In addition to the above redesign considerations, the crew members noted that Night Vision Goggle (NVG) compatibility will need to be a driver in the redesign process. Another general cockpit consideration mentioned by several crew members is to provide adjustable panel lighting. Accomplishing these recommendations should go a long way toward improving what is already an acceptable cockpit.

CONCLUSIONS

In terms of the TRAC program objectives, the Strategic Demonstration was a success. The evaluation of the TRAC cockpit functional baseline marked the first steps in the derivation of crew station design criteria. The development, test, and evaluation of a mission-driven crew station design was forwarded by having operational pilots from a variety of transport aircraft fly simulated missions in TRAC under varying workload conditions. In successfully completing the Strategic Demonstration, a tactical transport crew station design process has begun with the validation of an initial cockpit configuration.

The objectives of the Strategic Demonstration itself were also met. A functional baseline for (1) primary flight, (2) communication and navigation, and (3) aircraft systems operations were established under two levels of task loading. The secondary objectives of this study, the evaluation of the functionality and mechanization of the control and display interfaces, were also successfully accomplished for primary flight, communication/navigation, and aircraft systems operations.

The ensuing redesign process can now begin. A crew station working group will be assembled to determine the required control and display modifications. These will be actualized and re-evaluated in the next phase of the TRAC program, the Tactical Deployment. Functional specifications will also be provided for each of the display configurations. A sample functional specification is provided in Appendix I.

REFERENCES

Barbato, G. J., Sexton, G. A., Moss, R. W., and Brandt, W. R. (1980). Tanker Avionics/Aircrew Complement Evaluation (TAACE), Phase 0 - Analysis and Mockup, AFWAL-TR-80-3030.

Cone, S. M. and Hassoun, J. A. (1992). Precision Guided Weapons Employment in Single Seat Fighters: A Pilot Workload Assessment; (ASD-TR-92-5011), Wright-Patterson AFB, OH.

Geiselhart, R., Schiffler, R., and Ivey, L. J. (1976). A Study of Task Loading Using a Three-Man Crew on a KC-135 Aircraft, ASD-TR-76-19, Wright-Patterson AFB, OH.

Hughes Training, Incorporated. C-141 Pilot Requalification Course - Flight Pilot Guide. (Document No. 4P3-22), Altus AFB, OK: Hughes Training, Inc, 1992.

Madero, R. P., Barbato, G. J., Moss, R. W. (1981). Tanker Avionics/Aircrew Complement Evaluation (TAACE), Phase 1 - Simulation Evaluation, Vol 1: Results, (AFWAL-TR-81-3127), Wright-Patterson AFB, OH.

Reid, G. B. and Colle (1988). Critical SWAT Values for Predicting Operator Overload. In The Human Factors Society - 32nd Annual Meeting - 1988, Anaheim, CA.

Reid, G. B., Potter, S. S., and Bressler, J. R. (1989). Subjective Workload Assessment Technique (SWAT): A User's Guide, (AAMRL-TR-89-023), Wright-Patterson AFB, OH.

Rueb, J. D., Barnaba, J. M., Hassoun, J. A., Dudley, R. A., and Ward, G. F. (1992). KC-135 Crew Reduction Feasibility Demonstration Simulation Study Vol. 3: Test and Evaluation; (ASD-TR-92-5004), Wright-Patterson AFB, OH.

Schiffler, R. J., Geiselhart, R., and Griffin, J. C. (1978). A Study of Crew Task Loading on the C-141A Aircraft, (ASD-TR-78-1), Wright-Patterson AFB, OH.

Vidulich, M. A. (1989). The Use of Judgment Matrices in Subjective Workload Assessment: The Subjective Workload Dominance (SWORD) Technique. In proceedings of Human Factors Society 33rd Annual Meeting, Vol. 2, (pp. 1406-1410). Santa Monica, CA: Human Factors Society.

APPENDIX A
TRAC SYSTEMS DESCRIPTION

TRAC MULTIFUNCTION DISPLAY (MFD) SYSTEMS HANDOUT

I. GENERAL

Contained in this section is the systems layout and functional description. The TRAC simulator controls and displays and their functions will be discussed. For each system there will be a description of the system, including controls associated with that system, followed by a pictorial representation.

II. HEAD UP DISPLAY (HUD).

The HUD is displayed on the Out-The-Window CRT located above the glare shield directly in front of the pilot (Figure A-1). The following symbology is displayed on the HUD.

1. **Heading Indicator.** The heading indicator is displayed across the top of the HUD. The indicator consists of a horizontal tape displaying heading in tens of degrees, a heading box centered on the heading tape displaying aircraft present heading in degrees and a heading lubber line.
2. **Airspeed Indicator.** The airspeed indicator is displayed centered on the left side of the HUD. A round dial, consisting of 10 dots makes up the basic indicator. Each dot represents 1 knot of airspeed. In the center of the indicator is a digital readout of present airspeed and a mode indicator at the top of the display show the airspeed mode (i.e. Ground, Indicated, True, or Calibrated airspeed).
3. **Altimeter.** The altimeter is displayed centered on the right side of the HUD. It is identical to the airspeed indicator in format with each dot representing 10 feet of altitude. The mode indicator at the top of the display shows altitude as either Above Ground Level (AGL), or Mean Sea Level (MSL).
4. **Climb/Dive Ladder.** The Climb Dive Ladder is centered on the HUD and is scaled in 5-degrees increments. The lines above the center horizon line are solid whereas the lines below the horizon line are hashed for easy distinction between climb and dive.
5. **Climb Dive Marker.** The climb dive marker (CDM) is centered on the HUD and moves up and down to indicate aircraft climb or dive vector. The symbol resembles an upside down "U" with three lines, one each located at the nine, twelve and three o'clock positions.
6. **Flight Path Marker.** The Flight Path Marker displays the actual aircraft flight path. The symbol resembles a small circle with three lines, one each located at the nine, twelve, and three o'clock positions.
7. **Bank Indicator.** The bank scale is located at the bottom center of the HUD. It is incremented every 10 degrees through 30 degrees of bank, with each 30-degree increment highlighted with a longer index line. To minimize clutter, the bank scale beyond 30 degrees is not displayed until the aircraft bank approaches 30 degrees, at which time the 45-, 60-, and 90-degree indices come into view as aircraft actual bank approaches the indices prior to it. Actual bank is indicated by a triangular bank pointer.
8. **Timing Box/Baro Altitude Setting.** A timing box and baro altimeter setting are displayed at the bottom right side of the HUD.
9. **Navigation Box.** The navigation box is displayed on the bottom left side of the HUD. It contains ground speed, mach number, and waypoint information.

III. PRIMARY FLIGHT FORMAT (PFF).

The PFF can be selected on any MFD. It consists of an EADI and EHSI display centered one above the other respectively (Figure A-2). A tape style airspeed indicator is displayed on the left side of the EADI and a tape style altimeter is displayed on the right side of the EADI. A vertical velocity tape is located between the right edge of the EADI and the altimeter. All other information on the EADI and EHSI are standard instrument format and self explanatory.

Controls for this display consist of: 1) Programmable Display Pushbuttons (PDPs), located on the bottom of the display, 2) Heading Select Knob, Airspeed Select Knob, Lateral Navigation (LNAV) push button, and Vertical Navigation (VNAV) push button located on the Automatic Flight Control System (AFCS) panel, and 3) Communication/Navigation Control Panel (CNCN) and associated keypad. Function and operation of the AFCS and CNCN controls will be discussed in their respective sections later in this attachment. Below is a description of the PDPs and their function.

PDPs. PDPs for control of all MFDs are located below each MFD. For the purposes of this attachment PDPs will be identified as 1 through 20 starting at the top left hand PDP and moving left to right and then to the second row of PDPs again starting at the left and moving right. The PDPs for the Primary Flight Display are as follows:

PDP "1". Flight Director Queue. This PDP controls the flight director queue displayed on the EADI. The options available are: 1) "NO FDQ" which removes steering queues from the EADI, 2) "BAL" which displays a ball type steering queue on the EADI, and 3) "BAR" which displays vertical and horizontal steering bars on the EADI.

PDP "2". EHSI Heading Box. This PDP controls the information displayed in the heading box at the top of the EHSI. The Options are: 1) "TRK" which displays the aircraft track in degrees, and "HDG" which displays the aircraft Heading in degrees.

PDP "3". EHSI Compass Information. This PDP controls the type of heading displayed on the EHSI compass rose. The options are: 1) "TRU" which displays true heading, 2) "MAG" which displays magnetic heading, and 3) "GND" which displays ground track. NOTE: This PDP currently does not change displayed information.

PDP "4". EHSI Wind Indicator. This PDP controls the wind information displayed on the EHSI. The options are: 1) "DFT" which gives right or left drift information, and 2) "WND" which displays magnetic wind information.

PDP "5". Automatic Flight Control Guidance. This PDP commands the AFCS steering mode. The options are: 1) "AFC HDG" which commands the AFCS to steer to the EHSI heading marker, and 2) "AFC TRK" which commands the AFCS to steer to the EHSI selected track.

PDP "6". Attitude Reference. This PDP controls which attitude reference the EADI will use. The options are: 1) "ATT IN1" which references INS #1, 2) "ATT IN2" which references INS #2, and 3) "AHR" which references aircraft gyro system.

PDP "7". Heading Reference. This PDP controls which heading reference the EHSI will use. The options are: 1) "HDG IN1" which references INS #1, 2) "HDG IN2" which references INS #2, and 3) "AHR" which references aircraft gyro system.

PDP "8". Automatic Direction Finding (ADF) #1 Bearing Pointer. This PDP selects or deselects the bearing pointer for ADF #1. Pressing the PDP will display the bearing pointer on the EHSI. Pressing the PDP a second time will remove the pointer from the EHSI. The PDP is labeled "ADF 1".

PDP "9". Tactical Air Navigation (TACAN) #1 Bearing Pointer. This PDP selects or deselects the bearing pointer for TAC #1. Pressing the PDP will display the bearing pointer on the EHSI. Pressing the PDP a second time will remove the pointer from the EHSI. The PDP is labeled "TAC 1".

PDP "10". VHF Omnibus Receiver (VOR) #1 Bearing Pointer. This PDP selects or deselects the bearing pointer for VOR #1. Pressing the PDP will display the bearing pointer on the EHSI. Pressing the PDP a second time will remove the pointer from the EHSI. The PDP is labeled "VOR 1".

PDP "11". Main Menu Selection. This PDP returns the PDPs to the Main Menu. This PDP is labeled "MNU".

PDP "12". Horizontal Situation Format (HSF). This PDP selects the HSF format and associated PDPs. This PDP is labeled "HSF".

PDP "13". Perspective Format (PER). This PDP selects the PER format and associated PDPs. This PDP is labeled "PER".

PDP "14". Vertical Profile (VPF). This PDP selects the VPF format and associated PDPs. This PDP is labeled "VPF".

PDP "15". EHSI Format. This PDP selects the EHSI display format. The options are: 1) "FUL EHSI" which displays a full EHSI with a 360 degree compass rose, and 2) "PRT EHSI" which displays a partial EHSI and compass rose. NOTE: The partial EHSI function is TBD.

PDP "16". EADI Gyro Cage/Uncage. This PDP is used to cage/uncage the EADI. This PDP currently does not change EADI status.

PDP "17". This PDP is Blank.

PDP "18". ADF #2 Bearing Pointer. This PDP selects or deselects the bearing pointer for ADF #2. The PDP is labeled "ADF 2". Pressing the PDP will display the bearing pointer on the EHSI. Pressing the PDP a second time will remove the pointer from the EHSI.

PDP "19". TAC #2 Bearing Pointer. This PDP selects or deselects the bearing pointer for TAC #2. The PDP is labeled "TAC 2". Pressing the PDP will display the bearing pointer on the EHSI. Pressing the PDP a second time will remove the pointer from the EHSI.

PDP "20". VOR #2 Bearing Pointer. This PDP selects or deselects the bearing pointer for VOR #2. The PDP is labeled "VOR 2". Pressing the PDP will display the bearing pointer on the EHSI. Pressing the PDP a second time will remove the pointer from the EHSI.

NOTE: (PDPs 8 - 10 and 18 - 20). The system will not allow a navaid bearing pointer to be displayed if a valid signal is not being received.

IV. HORIZONTAL SITUATION FORMAT (HSF).

The Horizontal Situation Format (HSF) can be selected on any MFD (Figures A-3 and A-4). It consists of a selected route, map display referenced to a miniature aircraft. The display has range rings and a heading reference scale. Way points, desired track and other position awareness information can be selected/deselected at the pilots discretion.

Controls for this display consist of Programmable Display Pushbuttons (PDPs), located on the bottom of the display. Below is a description of the PDPs and their function.

PDPs. PDPs for control of all MFDs are located below each MFD display. For the purposes of this attachment, PDPs will be identified as 1 through 20 starting at the top left-hand PDP and moving left to right and then to the second row of PDPs again starting at the left and moving right. The PDPs for the HSF are as follows:

PDP "1". Declutter. This PDP controls the symbology displayed on the HSF. The options are: 1) "DCL 0" which displays all available symbology on the HSF, 2) "DCL 1" which removes non-flight plan airports, soft way points, drop zone corridor, and wind information, 3) "DCL 2" which removes heading readout box/numeric, heading reference general nav aids, way point constraint data, and tanker holding pattern, 4) "DCL 3" which removes way point identifiers, range rings/numeric, FEBA, and Infrared (IR) pointing reference arrow.

PDP "2". Navigation Aids. This PDP allows for the blanket selection/deselection of database navaid display on the HSF. This PDP is labeled "NAV AID".

PDP "3". Airport Symbology. This PDP allows for the blanket selection/deselection of all airports within the selected range of the HSF. This PDP is labeled "APT".

PDP "4". Weather Symbology. This PDP allows for the blanket selection/deselection of weather graphics. This PDP is labeled "WX".

PDP "5". Reroute Activation. This PDP allows for the manual activation of a mission replan either around the nearest threat, weather area, or to/from crew member designated coordinates. This PDP is labeled "RE-RTE".

PDP "6". Formation Symbology. This PDP allows for the blanket selection/deselection of formation aircraft and other formation pertinent information within the range selected on the HSF. This PDP is labeled "FLT FRM".

PDP "7". Drop Zone Symbology. This PDP allows for the blanket selection/deselection of drop zone and all associated symbology. This PDP is labeled "DZ SYM".

PDP "8". Background Imagery. This PDP controls the background image displayed on the HSF. The options are: 1) "BCK OFF" which displays a blank black background, 2) "DIG CHT" which displays a digital chart, 3) "DT" which displays DTED mapping information, 4) "TF RDR" which displays TF/TA radar ground mapping, and 5) "DT/DF" which displays DTED and DFAD mapping information.

PDP "9". Aircraft Position. This PDP controls the aircraft position on the HSF. Each activation of the PDP will cycle the aircraft one position. The three selectable positions are: 1) bottom-centered, 2) middle-centered, and 3) top-centered of the display.

PDP "10". Format Range Up. This PDP controls the selection of range scale in the "increase range" direction only. Ranges are displayed in nautical miles and are dependent on aircraft position on the HSF. The following ranges and scales will be displayed: 1) Aircraft Bottom: 5/10/15; 10/20/30; 20/40/60; and 40/80/120, 2) Aircraft Middle: 5/10; 10/20; 20/40; and 30/60, and 3) Aircraft Top: 5/10/15; 10/20/30; 20/40/60; and 40/80/120.

PDP "11". Main Menu Selection (MNU). This PDP returns the PDPs to the Main Menu options. This PDP is labeled "MNU".

PDP "12". Sensor Format Selection (SNR). This PDP selects the SNR display and associated PDPs. This PDP is labeled "SNR".

PDP "13". Preview Format Selection (PVU). This PDP selects the PVU display and associated PDPs. This PDP is labeled "PVU". NOTE: The PVU format currently consists of the alternate engine format display.

PDP "14". Vertical Profile (VPF). This PDP selects the VPF display and associated PDPs. This PDP is labeled "VPF". (The VPF is TBD).

PDP "15". Split Screen Option. This PDP allows the Vertical Profile and the Horizontal Profile to be displayed simultaneously, with the HSF on the bottom. Selecting another display with the HSF in the Split Screen mode will display the selected format and upon return to the HSF, Split Screen mode will still be active. This PDP is labeled "SPL SCN".

PDP "16". Split Screen PDP Options Selection. This PDP selects which format's PDPs will be available when two formats are displayed during Split Screen mode. The options are 1) "TOP" which allows the PDPs for the format displayed on the top half of the Split Screen to be available and 2) "BTM" which allows the PDPs for the format displayed on the bottom half of the Split Screen to be available. When Split Screen is not displayed, this PDP is inactive.

PDP "17". Timing Bus Symbolology. This PDP controls the selection/deselection of the Timing Bus Symbol. The Timing Bus represented by a rectangular box positioned along the route of flight, gives aircraft position relative to Flight Plan Timing. If the Bus is behind the aircraft symbol, the aircraft is ahead of scheduled flight plan timing, if the bus is ahead of the aircraft symbol, the aircraft is behind scheduled flight plan timing, and if the symbols are super-imposed, the aircraft is on scheduled flight plan timing. This PDP is labeled "BUS".

PDP "18". Flight Path Symbolology. This PDP controls the blanket selection/deselection of the Flight Path Symbolology. This PDP is labeled "FLT PTH".

PDP "19". Wind Data. This PDP controls the blanket selection/deselection of wind information on the HSF. When selected the vector arrow, magnitude and direction of the wind is displayed. This PDP is labeled "WND".

PDP "20". Format Range Down. This PDP controls the selection of range scale in the "decrease range" direction only. Ranges are displayed in nautical miles and are dependent on aircraft position on the HSF. The following ranges and scales will be displayed: 1) Aircraft Bottom: 5/10/15; 10/20/30; 20/40/60; and 40/80/120, 2) Aircraft Middle: 5/10; 10/20; 20/40; and 30/60, and 3) Aircraft Top: 5/10/15; 10/20/30; 20/40/60; and 40/80/120.

V. ENGINE STATUS / ENGINE FORMATS (ENG1 AND ENG2).

The ENG1 and ENG2 formats can be selected on any MFD (Figures A-5 and A-6). They contain engine and systems information, which is normally displayed on aircraft engine instrument and overhead panels, combined in a single MFD. Information is displayed in both tape and digital readout form and consists of: 1) Engine Performance Parameters (i.e. EPR, N1, N2, EGT), and 2) Systems Operating Parameters (i.e. Oil temperature, pressure and quantity; fuel flow and quantity etc.). The information presented in the ENG1 and ENG2 displays is identical and varies only in format.

An Automatic Caution And Warning System (ACAWS) advisory area is located at the bottom of the display. This area will display systems malfunctions and advisories in order of significance using color coded text messages (green for advisory, amber for cautions, and red for warnings). The messages will be displayed until the condition is resolved and systems operations are back to normal.

Controls for this display consist of Programmable Display Pushbuttons (PDPs), located on the bottom of the display.

PDPs. PDPs for control of all MFDs are located below each MFD display. For the purposes of this attachment PDPs will be identified as 1 through 20 starting at the top left hand PDP and moving left to right and then to the second row of PDPs again starting at the left and moving right. The PDPs for the Horizontal Situation Display are as follows:

PDP "1". This PDP is blank.

PDP "2". Fuel System. This PDP controls the blanket selection/deselection of the aircraft fuel system format. Symbolology/text displayed in yellow indicates a system malfunction. This PDP is labeled "FUL".

PDP "3". Electrical System. This PDP controls the blanket selection/deselection of the aircraft electrical system format. Symbolology/text displayed in yellow indicates a system malfunction. This PDP is labeled "ELE".

PDP "4". Auxiliary Power Unit System (APU). This PDP controls the blanket selection/deselection of the aircraft APU system format. Symbolology/text displayed in yellow indicates a system malfunction. This PDP is labeled "APU".

PDP "5". Hydraulic System. This PDP controls the blanket selection/deselection of the aircraft hydraulic system format. Symbolology/text displayed in yellow indicates a system malfunction. This PDP is labeled "HYD".

PDP "6". Environmental Control (ECS) System. This PDP controls the blanket selection/deselection of the aircraft ECS system format. Symbolology/text displayed in yellow indicates a system malfunction. This PDP is labeled "ENV".

PDP "7". Pneumatic System. This PDP controls the blanket selection/deselection of the aircraft pneumatic system format. Symbolology/text displayed in yellow indicates a system malfunction. This PDP is labeled "PNU".

PDP "8". Cargo System. This PDP controls the blanket selection/deselection of the aircraft cargo system format. Symbolology/text displayed in yellow indicates a system malfunction. This PDP is labeled "CGO".

PDP "9". This PDP is blank.

PDP "10". Scroll Up. This PDP allows for scrolling up through the Automatic Caution and Warning System (ACAWS) messages displayed in the ACAWS area located at the bottom of the ENG1 and ENG2 formats.

PDP "11". Main Menu Selection (MNU). This PDP returns the PDPs to the Main Menu options. This PDP is labeled "MNU".

PDP "12". Checklist Format (CHK). This PDP selects the CHK display and associated PDPs. This PDP is labeled "CHK".

PDP "13". Preview Format Selection (PVU). This PDP selects the ENG2 display and associated PDPs. This PDP is labeled "PVU". NOTE: The ENG2 format currently consists of the alternate engine format display.

PDP "14". Perspective Format (PER). This PDP selects the PER display and associated PDPs. This PDP is labeled "PER".

PDP "15" through "19". These PDPs are blank.

PDP "20". Scroll Down. This PDP allows for scrolling down through the Automatic Caution and Warning System (ACAWS) messages displayed in the ACAWS area located at the bottom of the ENG/PVU formats.

VI. CHECKLIST FORMAT (CHK).

The CHK formats can be selected on any MFD (Figures A-7, A-8, and A-9). They contain checklist information for normal, abnormal and emergency procedures which are contained in the aircrew flight manual. The main menu format (Figure A-7) displays the checklist submenu selections available for the various flight phases/operating procedures, (i.e. Normal Procedures, Emergency Procedures, Air Refueling, Tactical, Etc.). Once a submenu (Figure A-8) is selected the checklists available for that phase of flight (Figure A-9) will be displayed for operator selection.

Controls for this display consist of Programmable Display Pushbuttons (PDPs), located on the bottom of the display. Below is a description of the PDPs and their function.

PDPs. PDPs for control of all MFDs are located below each MFD display. For the purposes of this attachment PDPs will be identified as 1 through 20 starting at the top left-hand PDP and moving left to right and then to the second row of PDPs again starting at the left and moving right. The PDPs prefaced with an asterisk will only be available when on a menu or submenu page. When on a checklist page these PDPs will be blank. The PDPs for the Checklist Display are as follows:

PDP "1". Emergency Menu Select. This PDP calls up the emergency checklist menu and is always presented. This PDP is labeled "EMC".

PDP "2". Main Menu Select. This PDP calls up the main menu. This PDP is labeled "CHK MNU".

PDP "3". Automatic Mode. This PDP controls the selection/deselection of the automatic checklist function. This PDP is labeled "ATO".

PDP "4". Voice activation mode. This PDP controls the selection/deselection of the voice activated checklist. This PDP is labeled "VCE".

PDP "5". Undo. This PDP undoes the most recent checklist function accomplished. This includes checklist item, menu select, back up, skip and so forth. When selected the checklist display will return to the state just prior to the most recent selected function. Initiating the undo function a second time will undo the next selection, a third time undoes the next and so on. This PDP is labeled "UN DO".

PDP "6". Back Up. This PDP allows the operator to back up one sub-menu level at a time. This PDP is labeled "ENV".

PDP "7". Return. This PDP allows the operator to return to a checklist that was exited prior to completion. This PDP is labeled "RTN".

PDP "8". Skip. This PDP allows the operator to skip the current checklist item and continue the checklist from that point. The system will not allow completion of a checklist until all items are complete, and will automatically return to skipped item in sequence once the end of the checklist has been reached. This PDP is labeled "SKP".

PDP "9". Okay. This PDP is used to indicate a checklist item has been completed. This PDP is labeled "OK".

PDP "10". Scroll Up. This PDP allows for scrolling up through the checklist a page at a time. This PDP is labeled with an up arrow.

PDP "11". Format Menu. This PDP allows the operator to change the Main Menu PDPs. This PDP is labeled "MNU".

PDP "12" through "19". Menu line items. These PDPs allow the operator to select menu line items to bring up the appropriate submenu or checklist. These PDPs are labeled "1" through "8" respectively.

PDP "20". Scroll Down. This PDP allows for scrolling down through the checklist a page at a time. This PDP is labeled with a down arrow.

VII. CNCP DISPLAY FORMAT.

The Communication/Navigation Control Panel display depicts all communication and navigation information in two alternately selectable formats (COMM and NAV). The top line of each format is a title line as well as status advisory areas for IFF Identification/Emergency and Have Quick functions; the second line is a scratchpad, and shows information in response to numeric keypad (NKp) hits as well as incoming message alerts. COMM, NAV, and IFF data are displayed in two columns adjacent to each of the four line select keys on both sides of the display; there are a total of 24 character spaces across the format. There are two lines of information adjacent to each line select key.

Across the bottom of the display are switches for the inflight positioning communication system. These switches have an alternate function and operation, and will be discussed in the Flight Command Indicaotr section on the following page.

NUMERIC KEYPAD (NKP). Two numeric keypads are located under the pilots' glare shield, between the Automatic Flight Control System Control Panel (AFCS) and the Communication/Navigation Control Panels (CNCP). The keypad is used in conjunction with communications and navigation radio selections, flight management settings, and IFF control.

The keypad (Figure A-10) has a total of 16 buttons containing the numbers "1-9", "0", "000", "/", ".", "C", "CA", and "-", and is used to make entries on the AFCS and the CNCP. The buttons are separated by key guards which reduce the potential of wrong key hits.

☐ Numbers 1-9, 0, 000: The number keys are used for entering channel numbers and frequency digits, as well as for entries on the AFCS panel (such as altitude, heading, etc.).

☐ CA: The "CA" key clears scratchpad entries one character at a time.

☐ C: The "C" key clears scratchpad of the entire current entry.

☐ /: The "slash" is used as a mandatory prefix for a 3 digit course/heading keypad entry.

☐ -: The "minus sign" is used to set negative values to entries such as minus elevations (Below sea level).

☐ .: The "decimal" is used to prefix partial frequency changes.

CNCP. The communication/navigation Control Panel (CNCP) controls and indicators are organized into the following functional groups:

Display. The display area depicts all CNC information as well as the Flight Command Information (FCI), a scratchpad area, and Have Quick/IFF ID annunciation alert area.

Line Select Keys (LSK). Switch keys adjacent to each side of the display area; used to control COMM/NAV selections.

MENU Switch. Toggles between the COMM and NAV formats.

IFF IDENT switch. A single switch (Labeled "ID") activates the IFF identification mode and illuminates the IDENT annunciator in the upper right corner of the CNCP display for 7 seconds. The switch is located on the upper right side of the CNC panel.

The acronym EMERG illuminates in the upper right corner of the CNCP display when IFF Mode 3 and code 7700 is selected. An emergency control switch located on a console panel also activates the Emergency function and tunes the transponder to 7700 (Mode 3).

IFF Standby/Normal switch. Single switch (Labeled "S/N") used to toggle between the Standby and Normal mode of the IFF. When the IFF is in Normal mode the setting for the selected mode appears in the display on the mode set line; when the IFF is in Standby mode, "STBY" appears in the display on the MODE SET line. The switch is located on the right side of the CNC panel.

Active Have Quick select switch. Single switch (Labeled "AHQ") used to activate the Have Quick communication function. Located on the left side of the CNC panel. The Have Quick function provides for UHF radio frequency "hopping" on a network of frequencies. When this feature is active an annunciator in the upper left corner of the CNCP display indicates "AHQ".

Before using Have Quick, the Time-Of-Day (TOD) and Word-Of-Day (WOD) modes must be initialized through controls on the center console CDU.

SCN switch. The SCN (Scan) switch toggles between the HF Scan modes. There are two scan modes; Basic Scan (BSCAN) and Enhanced Scan (ESCAN). Except for mode selection, all BScan and EScan functions are controlled from the mission computer keypad/display CDU.

BScan scans the HF channels for a single designated HF station (stored in the HF database) and will work with all stations. EScan provides for scanning of multiple HF stations if desired, filtering out non-desired stations, and will only work with stations/aircraft having similar type equipment.

BScan and EScan modes are indicated on the HF radio line by an "B" or "E" when selected.

Flight Command Indicator (FCI) select keys. A line of six switches (Labeled "←", "—", "↓", "E", "↑", "+", "→") used to select communications and navigation systems as primary for communicating with ground stations and for display on flight instruments. The "E" switch is used as a precursor to selecting a desired radio or navaid. After selecting the "E" switch the primary radio or navaid is selected by pressing its corresponding LSK. The radio/navaid title will reverse video to indicate it is primary. The "↓" and "↑" arrows are used in conjunction with the nav menu pages and is used to toggle between the two navigation menu pages.

Numeric Data Entry.

All frequency range formatting is mutually exclusive (see specific radio types below under COMM Format). Numeric information for the CNCP is entered on the NKp which is located between the CNCP and the AFCS panel. Decimals do not need to be entered on the NKp. If one, two, or three numbers are entered, the entry is recognized as a channel entry on those radios when channelization is appropriate (i.e., UHF, VHF, HF, TACAN, and MLS).

If a channel number or frequency number outside the appropriate range of a specific radio is entered, the entry in the scratchpad area will reverse video.

Secure Communication Control. Secure communications settings are controlled through the mission computer keypad. Audio volume for each of the radios is controlled through volume control switches on the interphone control panel. Secure communications status for each of the radios appears on the COMM format as follows:

S-(T, R, T/R) = Secure Comm - Cipher mode activated {Mode designator}.

P-(T, R, T/R) = Plain Comm - Cipher mode not activated {Mode designator}.

Mode designators:

T = Transmit - Cipher/Plain transmit only.

R = Receive - Cipher/Plain receive only.

T/R = Transmit and Receive - Cipher/Plain Transmit and Receive.

Line Select Keys (LSK). There are eight, bezel type, line select keys; four on each side of the display in the bezel. The LSKs control the input or selection of information or functions through the CNCP. The LSKs provide for

frequency changes and select modes of operation as well as indicate status. Labels for each key are on the screen area adjacent to the respective key.

COMMUNICATION FORMAT. In the COMM format (Figure A-11) the following labels appear adjacent to the LSKs: U1 (UHF-1), U2 (UHF-2), V1 (VHF-1), V2 (VHF-2), H1 (HF-1), H2 (HF-2), UGRD (UHF Guard), and VGRD (VHF Guard). The active frequency, operating mode, (S-P, and T-R-T/R), and corresponding preset channel number (if there is one assigned) for each radio appears adjacent to the radio type. Depressing any of the UHF, VHF, or HF switches, with the scratchpad empty, causes the respective radio to toggle between active and backup channel/frequency. There is an active and backup frequency for each radio. The backup channel/frequency is the channel/frequency which was previously active. The radio each pilot has selected for transmitting, (Primary), is highlighted by reverse video.

Channels/frequencies can be entered/changed by entering the appropriate numbers on the NKp, followed by selecting the respective radio LSK. The new channel/frequency entered replaces the active (displayed) channel/frequency; the channel/frequency which was active becomes the standby channel/frequency. If one or two digits are entered, the system will recognize the entry as a preset channel; three or more digits (trailing zeroes added) will identify a manual channel/frequency entry. Channel numbers are entered without preceding zeroes.

Decimals are not a required entry when selecting frequencies; however, decimals can be used to enter changes to frequencies wherein only the tenths or hundredth numeric changes. To change only the numerics to the right of the decimal (select the ".", enter the numerics, then select the desired radio LSK).

Numeric entries out of the accepted range of a selected radio will cause the scratchpad entry to reverse video.

UHF- Numeric entry by channel (1-25) - enter 1 or 2 digit channel number; numeric entry by frequency (Valid frequency range: 225.000-399.975MHz in 0.025 MHz steps); enter 3-6 digits; then select the UHF LSK; trailing numbers not entered default to zero.

VHF- Numeric entry by channel (1-25) - enter 1 or 2 digit channel number; numeric entry by frequency (AM: 118.000-151.975; FM: 30.0 to 87.975) - enter 3 - 6 digits; then select the "VHF" LSK; trailing numbers not entered default to zero.

HF- Numeric entry by channel (1-25) - enter 1 or 2 digit channel number; numeric entry by frequency (2000-29999.9) - enter 4 to 6 digits; then select the "HF" LSK; trailing numbers not entered default to zero.

UGRD- Displays active UHF Guard frequency (243.0 MHz). Cursor placement indicates whether it is set to transmit or to only monitor guard frequency. Selecting the LSK toggles between MONITOR and transmit (UGRD) positions.

VGRD- Displays active VHF Guard frequency (121.5 or 40.5 FM MHz). Cursor placement indicates whether it is set to transmit or to only monitor guard frequency. Selecting the LSK toggles between MONITOR and transmit (VGRD) positions.

GPS- Displays GPS information: TBD

NAV FORMAT. VOR1, VOR2, TAC1, TAC2, ADF1, ADF2, ILS, and MLS, refer to types of navigation radios (Figures A-12 and A-13). IFF control is also available on this format. The type of radio, station identifier, frequency of the tuned NAV radios and selected courses are displayed. The station ICAO identifier associated with the frequency appears next to the type radio (i.e., TAC1/FFO).

The default NAV format shows the active navigation radios, active frequencies and station identifiers, and nav radio status. When the nav radio is off, the word "OFF" will appear under the radio type. When the nav radio is

"ON" the frequency or channel is displayed under the radio type. The display for VOR, TACAN, and ADF will show either the number "1" or "2" at all times.

ENTERING NAVIGATION AIDS. Entry is by frequency or ICAO designator through the glare shield NKp, or the alphanumeric mission computer keypad. If a valid signal is being received both the navaid ID and frequency will appear on the NAV CNCP display. If a valid signal is not being received, only that entry which was selected will appear on the display until the signal is received. That is, if the frequency is entered but not being received, only the frequency will appear under the type radio; if the ICAO designator is entered and a signal is not being received, only the ICAO designator will appear next to the type radio until the proper signal is received.

ICAO designator entries require two to four alpha entries, followed by LSK selection of the type radio desired.

Navaid entry by frequency is as follows:

VOR: To enter a frequency, 3-5 digits are entered on the NKp, then the "VOR" LSK on the CNCP is selected. Frequency range is 108.00 - 117.95; the tenths digit cannot be an odd numeric when selecting frequencies between 108.0 and 112.0. Trailing digits not entered default to zeroes.

ILS: To enter a frequency, 4-5 digits are entered on the NKp, then the "ILS" LSK on the CNCP is selected. Frequency range is 108.1 - 111.95; the tenths digit must always be an odd numeric. Trailing digits not entered default to a zero.

TACAN: Numeric entry by 1-3 digit channel number only. Enter the channel number on the NKp, then select the "TACAN" LSK (Valid entries: 1 -126). An alpha suffix of "X" or "Y" is used. The default suffix (X or Y) for TACAN is controlled through a CDU or through the LSK for the appropriate TACAN. The default position at turn on is receive-only (REC); an "R" character will appear adjacent to the ICAO identification letters to indicate the TACAN is in receive-only state.

ADF: Numeric entry by frequency in the range 190 - 1600. Enter the 3-4 digit frequency numbers on the NKp, followed by selecting the "ADF" LSK switch.

MLS: Numeric channel numbers in the range as follows:

5000 (first channel)

501 - 699 in one channel increments.

Enter 3-4 digit channel numbers on the NKp, followed by selecting the "MLS" LSK switch.

SIMULTANEOUS UPDATE OF NAVAID AND COURSE. To enter a frequency and a course at the same time (usually when a navigation radio is changed the course changes also), the pilot selects the frequency numerics followed by a "/", then a 3-digit course numeric, and selects the appropriate navigation radio LSK (leading zeroes are not required).

UPDATE OF COURSE ONLY. To enter a course without changing the station frequency the pilot enters "/" followed by a 3-digit course numeric, then the appropriate LSK. The default course type for the NAV radios is magnetic. Changes to the course type are controlled through the Mission Computer Keypad/Display.

IFF MODE/CODE. The "IFF SET" LSK toggles through the 5 IFF modes (1,2,3,C,4) in sequence. If the IFF is OFF, it can be turned ON by selecting this switch. The default turn-on mode is 3. When the IFF is on, the setting/status information appears adjacent to the IFF SET LSK. It shows the code settings for modes 1 and 3, the IN or OUT status for modes 2, 3C, and 4, as well as the ON or OFF status (see attached NAV CNCP format).

Settings are made as follows:

1. Select the desired mode with the IFF SET LSK, then: Modes 1 and 3 (actually 3A): Enter the mode numbers in the NKp, and select the IFF SET LSK. Modes 2, C (Actually 3C), and 4: Select the IFF SET LSK. (For

these modes the Standby/Normal (S/N) switch will toggle the mode IN/OUT. Mode C cannot be IN unless Mode 3 is ON).

2. An alternate method to set Mode 1, 2, and 3 is: Enter 2, 3, or 4 digits on the NKp, then select the IFF SET LSK. For Mode 1, enter two numbers; for Mode 2, enter the number "2", plus two code numbers; for Mode 3, enter a four digit number.

VIII. AUTOMATIC FLIGHT CONTROL SYSTEM.

The AFCS panel (Figure A-14) provides the controls required to engage or disengage the autopilot, auto throttle, flight director, and altitude warning. It also provides these inputs to the mission computer system which drive the related flight modes displays on the HUD and MFDs.

The AFCS control panel is located in the middle of the glare shield between the two CNCPs to provide both pilots access to all switches and controls. This section contains a description of the system, including controls associated with that system, followed by a pictorial representation. Switches not address do not currently have a function.

APPROACH PATH SELECTOR AND INDICATOR. A rotary knob selector switch, labeled SEL, incorporating a momentary three position left-center-right function, spring loaded to the center position, and a push-button function, spring loaded to the out position, allows for selection and display of the desired value. The left-center-right function allows for selection in the decrease (left), and increase (right) direction, releasing the switch to the spring loaded position when the desired value has been attained. The push button function is then used to enter the selected value into the mission computer for use by the autopilot/auto throttle system.

The approach path indicator, located directly above the selector switch, displays flight path angles from 0.0 through 9.9 degrees in 0.1-degree increments. A push-button located above the indicator, labeled APPR PATH, allows the operator to accept values from the CNCP scratchpad. Scratchpad entries are made via the NKp (See CNCP Systems Handout above for specific operating instructions). The selected approach path angle is also displayed on the Primary Flight Display EHSI.

MACH NUMBER/INDICATED AIRSPEED (IAS) SELECTOR AND INDICATOR. A rotary knob selector switch, labeled SEL, incorporating a momentary three position left-center-right function, spring loaded to the center position, and a push-button function, spring loaded to the out position, allows for selection and display of the desired value. The left-center-right function allows for selection in the decrease (left), and increase (right) direction, releasing the switch to the spring loaded position when the desired value has been attained. The push button function is then used to enter the selected value into the mission computer for use by the autopilot/auto throttle system.

Two momentary push-button switches, one labeled MACH/IAS, and the other labeled THR/PITCH, alternately selects MACH or IAS and Thrust or Pitch axis, respectively, for display and manipulation. These switches are located left and right, respectively, of the selector switch.

A two position, (in/out), push button switch labeled SPD HOLD engages the autopilot system to either the IAS or MACH displayed on the MACH/IAS indicator. This switch is located directly below the selector switch. The switch illuminates to indicate the function is active.

The MACH/IAS indicator, located directly above the selector switch, displays MACH/IAS from 0.5 through 0.9 MACH in 0.001 increments and 100 through 450IAS in 1 knot increments. A push-button located above the indicator, labeled MACH/IAS, allows the operator to accept values from the CNCP scratchpad. Scratchpad entries are made via the NKp (See CNCP Systems Handout above for specific operating instructions). The selected airspeed is also displayed on the Primary Flight Display EADI as a reference line on the airspeed tape.

HEADING SELECTOR AND INDICATOR. A rotary knob selector switch, labeled SEL, incorporating a momentary three position left-center-right function, spring loaded to the center position, and a push-button function, spring loaded to the out position, allows for selection and display of the desired value. The left-center-right function allows for selection in the decrease (left), and increase (right) direction, releasing the switch to the spring loaded position when the desired value has been attained. The push button function is then used to enter the selected value into the mission computer for use by the autopilot/auto throttle system.

The heading indicator, located directly above the selector switch, displays heading from 000 through 359 degrees in 1 degree increments. A push-button located above the indicator, labeled HDG, allows the operator to accept values from the CNCP scratchpad. Scratchpad entries are made via the NKp (See CNCP Systems Handout above for specific operating instructions). The selected heading is also displayed on the Primary Flight Display EHSI by positioning the heading bug on the outer edge of the compass rose adjacent to the selected heading.

A two position, (in/out), push button switch labeled HDG HOLD, engages the autopilot system to heading displayed on the heading indicator. This switch is located directly below the selector switch. The switch illuminates to indicate the function is active.

BANK ANGLE SELECTOR AND INDICATOR. A rotary detent switch allows for the selection of maximum bank angle to be commanded by the autopilot. The switch located at panel center, is labeled 20, NORM, STD/2. These positions select 20 degrees, standard rate and 1/2 standard rate maximum turn rates respectively.

A two position switch for selecting roll rate, labeled ROLL RATE, is located at the bottom right of the AFCS panel. The top position allows for selection of a 5-degree /second-roll rate and is labeled NORM. The bottom position allows for selection of 3 degrees/second and is labeled MIN.

AUTO THROTTLE SYSTEM (ATS) SELECTOR AND INDICATOR. A three position (up-center down) switch, spring loaded to the center position, allows the operator to engage the auto throttle system. The auto throttle is engaged by moving the switch to the up, labeled "ON", position momentarily and then releasing it to the spring loaded center position. The system is disengaged by moving then releasing the switch to the down, labeled "OFF", position. The switch, located approximately panel center, is labeled ATS. This system, when engaged, ties the throttles to the speed function(s) designated by the mode switches located at the bottom of the AFCS panel. A green indicator light, located directly above the selector switch, turns on when the system is on and goes out when the system is off.

AUTOPILOT SYSTEM (AP) SELECTOR AND INDICATOR. A three position (up-center down) switch, spring loaded to the center position, allows the operator to engage the autopilot system. The autopilot is engaged by moving the switch to the up, labeled "ON", position momentarily and then releasing it to the spring loaded center position. The system is disengaged by moving then releasing the switch to the down, labeled "OFF", position. The switch, located approximately panel center, is labeled AP. This system, when engaged, ties the autopilot to the navigation function(s) designated by the mode switches located at the bottom of the AFCS panel. A green indicator light, located directly above the selector switch, turns on when the system is on and goes out when the system is off.

VERTICAL SPEED SELECTOR AND INDICATOR. Two three position (up-center down) switches, spring loaded to the center position, allows the operator to select and engage a desired rate of climb or dive. The rate is selected by holding the right switch in the up (increase) or down (decrease) position and then releasing when the desired value has been attained. The vertical speed mode is engaged by moving the left switch to the up position momentarily and then releasing it to the spring loaded center position to descend at the desired rate or moving the switch down and then releasing to climb at the desired rate.

The vertical speed indicator, located directly above the selector switches, displays vertical speed from 7000 feet per minute (fpm) UP through 19,900 fpm DOWN in 100 fpm increments. The first two characters displayed are either UP or DN to indicate the direction and the last four displays the rate times 10 rounded to the nearest 100 fpm. A push-button located above the indicator, labeled VERT SPD, allows the operator to accept values from the CNCP scratchpad. Scratchpad entries are made via the NKp (See CNCP Systems Handout above for specific operating instructions). The selected rate is also displayed on the Primary Flight Display EADI.

ALTITUDE SELECTOR AND INDICATOR. A rotary knob selector switch, labeled SEL, incorporating a momentary three position left-center-right function, spring loaded to the center position, and a push-button function, spring loaded to the out position, allows for selection and display of the desired value. The left-center-right function allows for selection in the decrease (left), and increase (right) direction, releasing the switch to the spring loaded

position when the desired value has been attained. The push button function is then used to enter the selected value into the mission computer for use by the autopilot/auto throttle system.

The altitude indicator, located directly above the selector switch, displays altitude from 000 through 50,000 feet in 10 feet increments. A push-button located above the indicator, labeled ALT, allows the operator to accept values from the CNCP scratchpad. Scratchpad entries are made via the NKp (See CNCP Systems Handout above for specific operating instructions). The selected altitude is also displayed on the Primary Flight Display EADI as a reference line on the altitude tape.

MISCELLANEOUS SWITCHES. Several additional switches are located along the bottom of the AFCS panel. They are:

SPLIT AXIS SWITCH. A momentary action switch, labeled SPLIT AXIS, allows the operator to only disengage the autopilot roll axis. This switch is located directly below the altitude selector switch.

TURBULENCE SWITCH. A momentary action switch, labeled TURB, allows the operator to set the autopilot to an attitude hold mode in both the pitch and roll axes. This switch is located to the left of the Split Axis selector switch.

PILOT ID SWITCH. A two position, lever lock toggle switch, labeled PILOT ID, allows the operator to designate which NAV mode and heading reference will be used for AFCS operation. Moving the switch to the left, labeled P, references to the pilot's selector, and moving the switch to the right, labeled CP, references the co-pilot's selector. This switch is located at center bottom panel.

IX. CONTROL DISPLAY UNIT.

The CDU contains the controls and displays for monitoring, updating and activating all flight plan data (Figures A-15 and A-16). The two formats which will be discussed in this section are the Flight Plan (FLT PLAN) page and the direct to (DIRECT TO) page. This section contains a description of the system, including controls associated with that system, followed by a pictorial representation.

CDU PANEL. The CDU panel (Figure A-15) depicts all flight plan information in two alternately selectable formats (FLT PLAN and DIRECT TO). The top line of each format is a title line, and the bottom line is a scratchpad which shows information in response to numeric keypad (NKp) hits. Flight Plan data are displayed in two columns adjacent to each of the four line select keys on the left side of the display.

ALPHANUMERIC KEYPAD (A/NKP). The A/NKp (Figure A-16) is used in conjunction with the CDU display panel for entering and updating flight plan information.

The keypad has a total of 51 buttons containing: 1) nine menu select buttons, 2) a number keypad area containing the numbers "1-9", "0", "000", and ".", and 2) an alpha keypad area containing the letters "A-Z", "+", "-", "/", and "CLR".

The menu select buttons are used to select the desired page formats indicated on the select button. The Flight Plan and Direct To formats are labeled "FLT PLN" and "D→" respectively.

The number keypad area is used to enter or update numeric data, such as, courses and distances, and to move a waypoint.

The alpha keypad area is used to update alphabetic data, such as, waypoint identifiers, and to add, delete, or change a waypoint.

FLIGHT PLAN FORMAT. The flight plan page displays the route of flight and other pertinent information (i.e. track to waypoint, time to waypoint, and distances to waypoint), to the pilot. To select the Flight Plan page, depress the menu select key labeled FLT PLN. The flight plan page is used to monitor, add, delete, or change a waypoint in the flight plan. The following procedures describe how to update the route of flight.

Add a waypoint (Figures A-17, A-18, A-19, A-20, and A-21). To add a way point first enter the three letter identifier for the waypoint by pressing the appropriate keys on the alpha keypad. The identifier will appear in the scratchpad at the bottom right-hand corner of the CDU (Figure A-18). After confirming you have entered the proper identifier, depress the LSK adjacent to the waypoint which occupies the place in the flight plan that the new waypoint will occupy (represented by the lighter shaded DEF in Figure A-18). Once the LSK is depressed, the new waypoint (XYZ) will be placed in the selected order, all subsequent waypoints will shift down one position, and the scratchpad will be erased (Figure A-20). Figures A-17 through A-21 are a pictorial representation of the CDU and HSF. The hashed lines and shaded waypoint on the HSF depictions are for reference only and will not actually appear on the display. The updated flight plan will be presented on both the CDU and the HSF presentation.

Delete a waypoint (Figure A-21, A-22, A-23, A-24, and A-25). To delete a waypoint first enter a minus sign by pressing the "-" key on the alpha keypad (Figure A-22).

After confirming you have entered the appropriate symbol in the scratchpad, depress the LSK adjacent to the waypoint you wish to delete. Once the LSK is depressed, the waypoint to be deleted (DEF) will be removed from the CDU, all subsequent waypoints will shift up one position, and the scratchpad will be erased (Figure A-24). Figures A-21 through A-25 are a pictorial representation of the CDU and HSF when deleting a waypoint. The hashed lines and shaded waypoint on the HSF depictions are for reference only and will not actually appear on the display. The updated flight plan will be presented on both the CDU and the HSF presentation.

Replace a waypoint (Figures A-25, A-26, A-27, A-28, and A-29). To replace a waypoint enter a minus sign followed by the identifier of the new waypoint by pressing the "-" key on the alpha keypad and the appropriate alpha characters (Figure A-26). After confirming you have made the appropriate entry in the scratchpad, depress the LSK adjacent to the waypoint you wish to replace. Once the LSK is depressed, the waypoint to be replaced (XYZ) will be removed from the CDU, the new way point will appear in its place, and the scratchpad will be erased (Figure A-28). Figures A-25 through A-29 are a pictorial representation of the CDU and HSF when replacing a waypoint. The hashed lines and shaded waypoint on the HSF depictions are for reference only and will not actually appear on the display. The updated flight plan will be presented on both the CDU and the HSF presentation. Note that the difference between adding and then deleting a waypoint, and replacing a waypoint, is that when a waypoint is replaced it will still be presented on the HSF but not as part of the route of flight.

Moving a waypoint (Figures A-29, A-30, A-31, A-32, and A-33). To move a waypoint first enter the bearing and distance you wish to move the waypoint (Figure A-30). After confirming you have made the appropriate entry in the scratchpad, depress the LSK adjacent to the waypoint you wish to move. Once the LSK is depressed, the waypoint to be moved (DEF) will be moved and the CDU, all display the new track and distance information for the waypoint, and the scratchpad will be erased (Figure A-32). Figures A-29 through A-33 are a pictorial representation of the CDU and HSF when moving a waypoint. The hashed lines and shaded waypoint on the HSF depictions are for reference only and will not actually appear on the display. The updated flight plan will be presented on both the CDU and the HSF presentation.

DIRECT TO FORMAT. The Direct To page displays the route of flight and other pertinent information (i.e. track to waypoint, time to waypoint, and distances to waypoint), to the pilot. The Direct To page is used to establish and fly from the aircraft's present position direct to a selected waypoint of the flight plan. To fly direct to a waypoint, select the Direct To page by depressing the "D→" menu select key. Once the Direct To page is displayed you can select a waypoint to fly direct to by depressing the LSK adjacent to the desired waypoint. The route direct to the selected waypoint will be displayed on the HSF.



Figure A-1. Head Up Display (HUD).

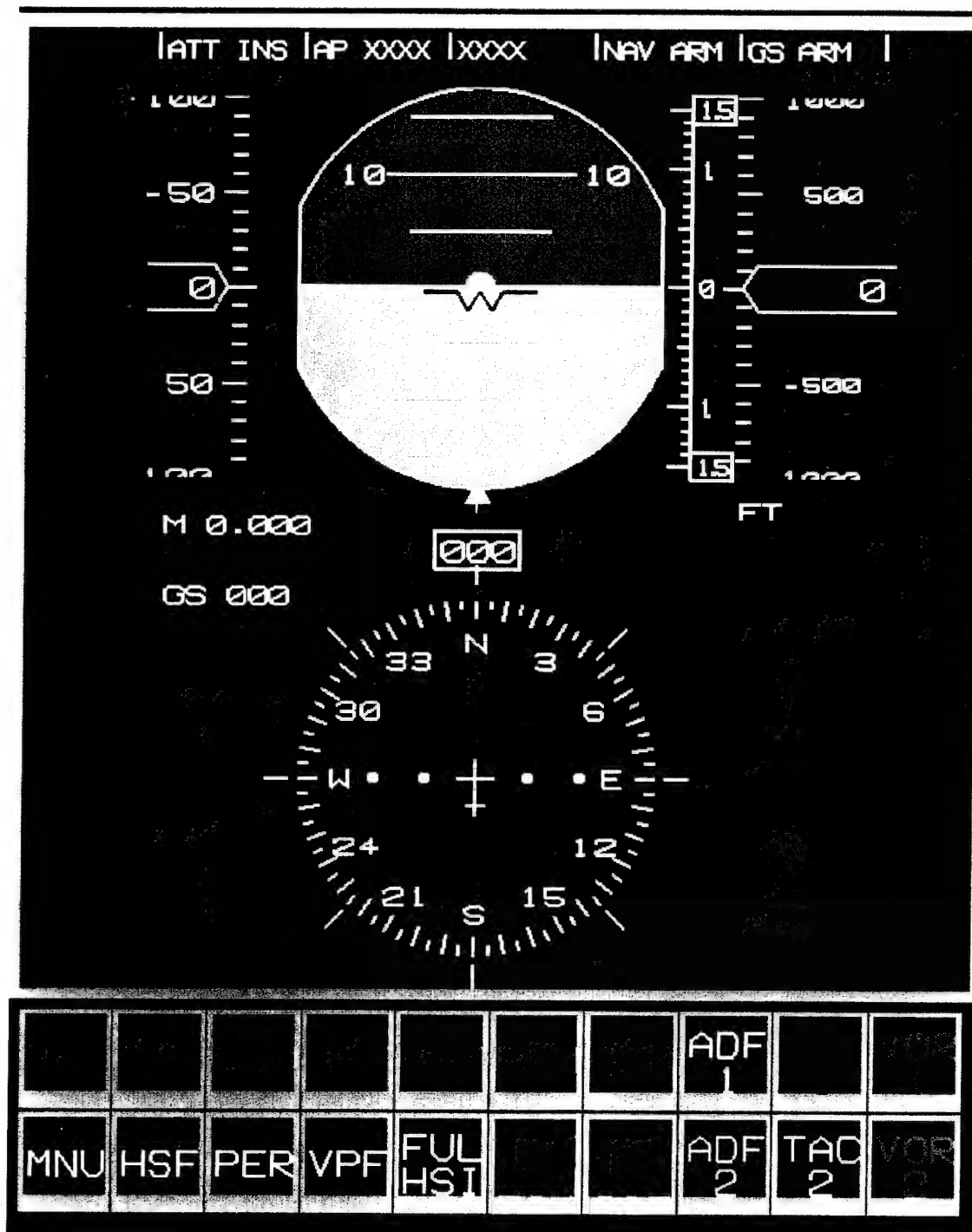


Figure A-2. Primary Flight Format (PFF).

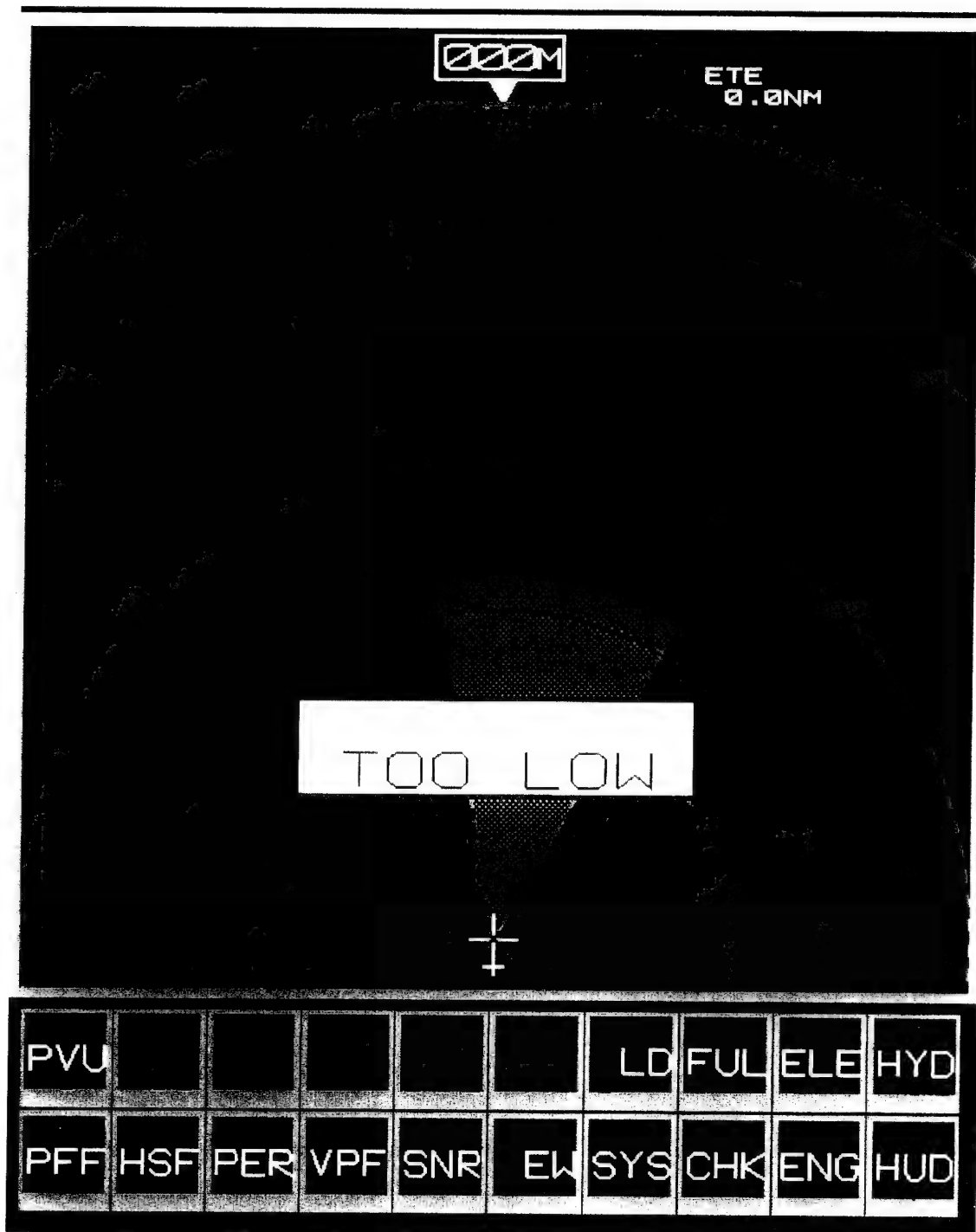


Figure A-3. Horizontal Situation Format (HSF) with primary PDP's.

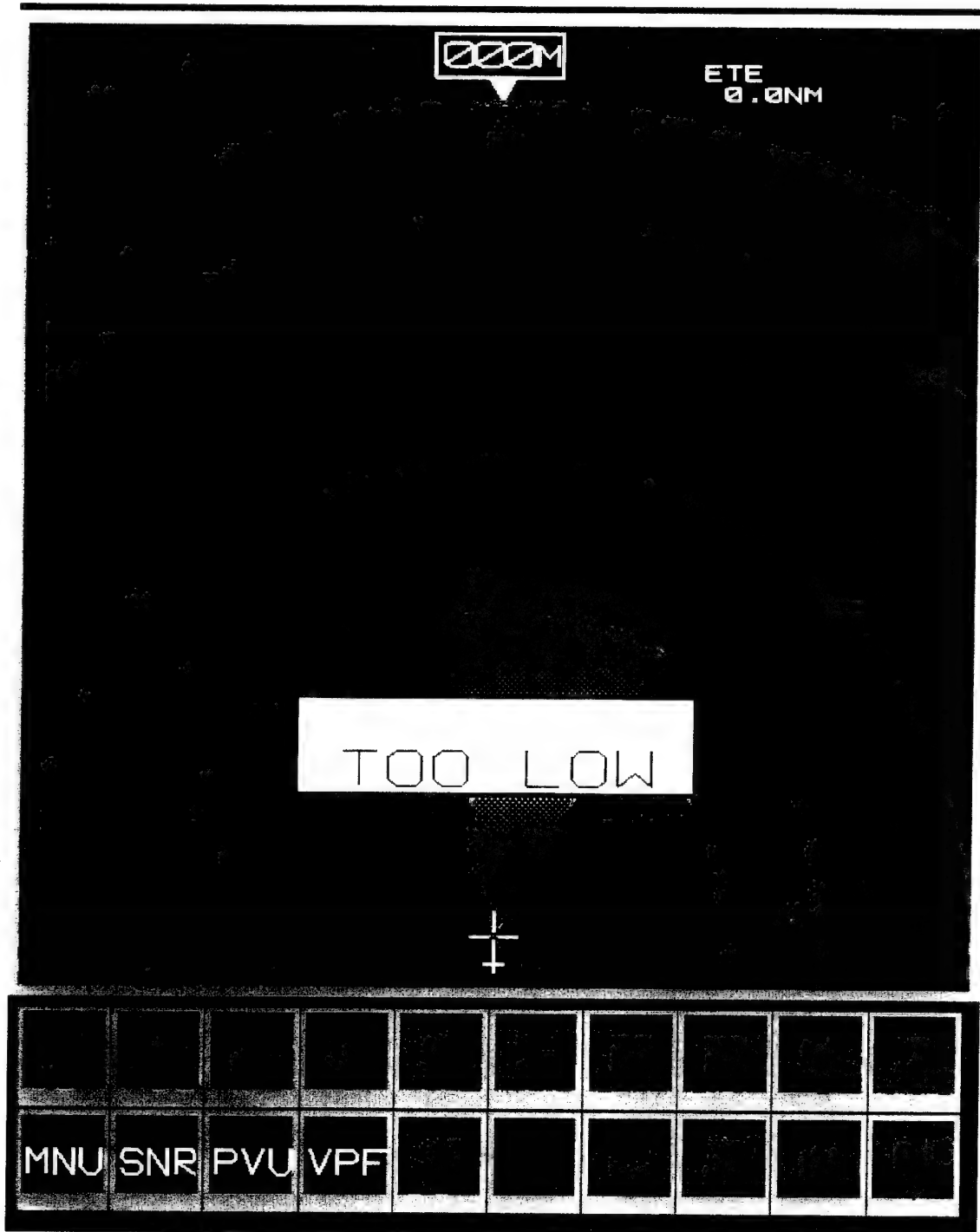


Figure A-4. Horizontal Situation Format (HSF) with all PDP's.

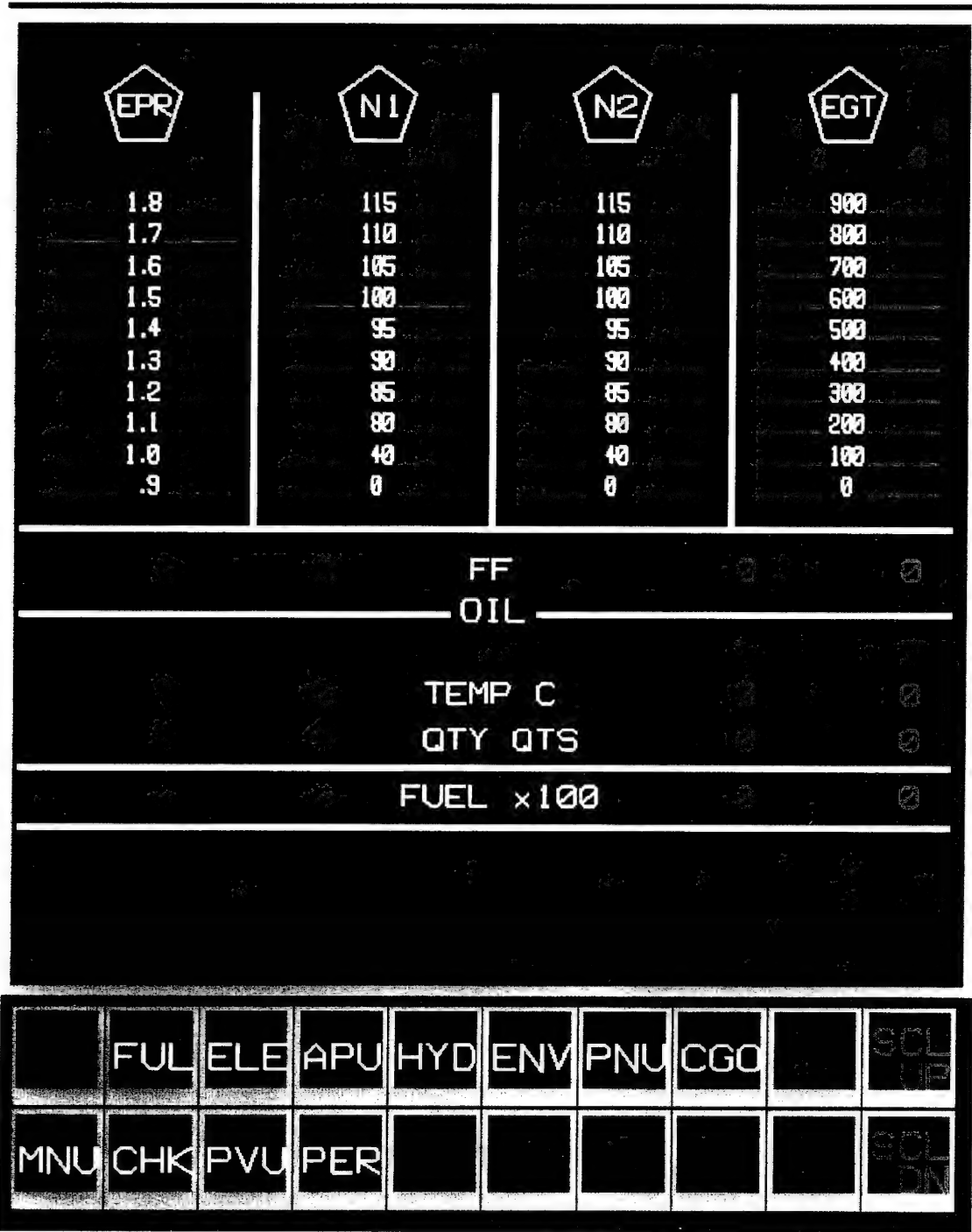


Figure A-5. Engine Display (ENG).

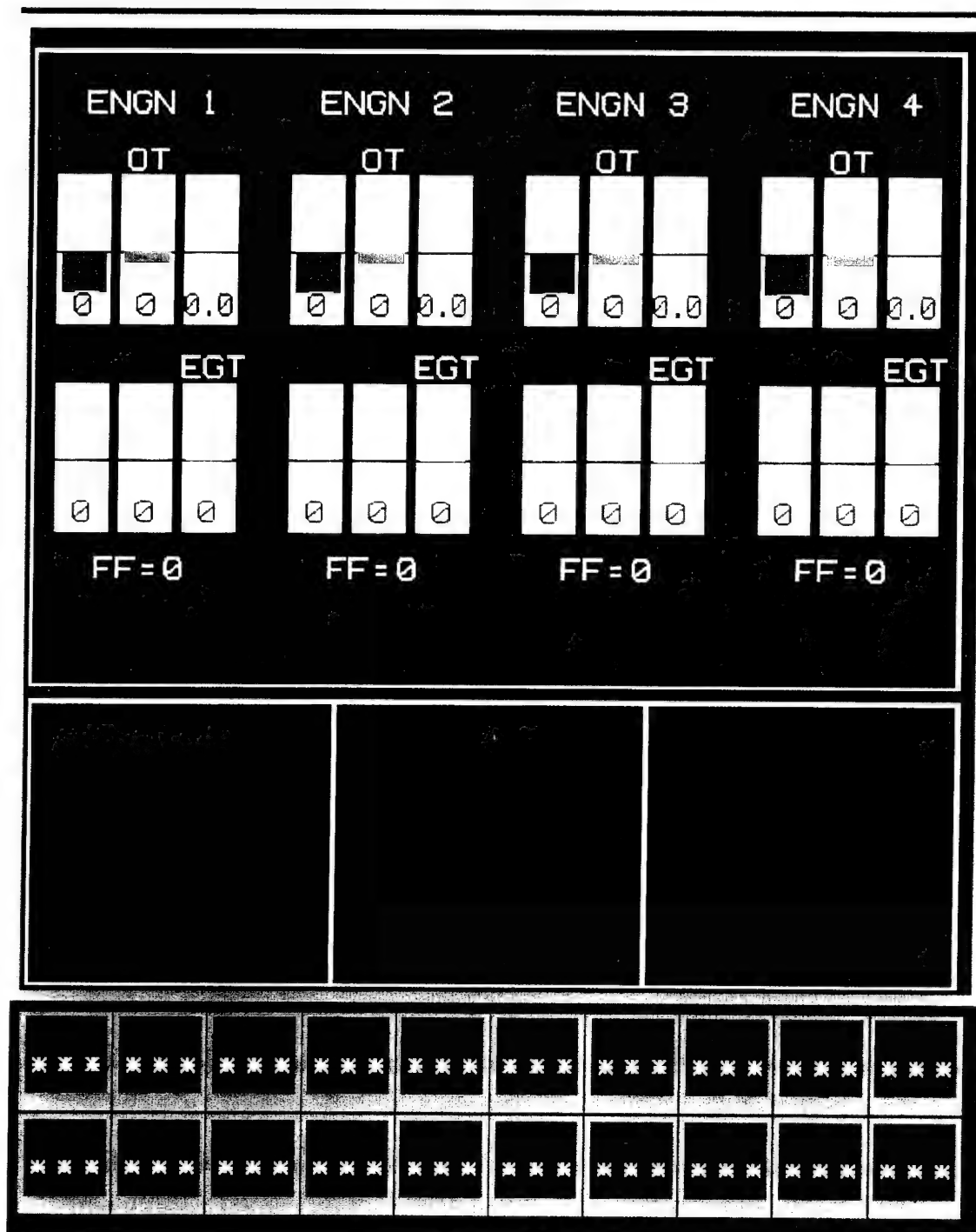


Figure A-6. Engine Monitoring and Control System Format (ENG2).

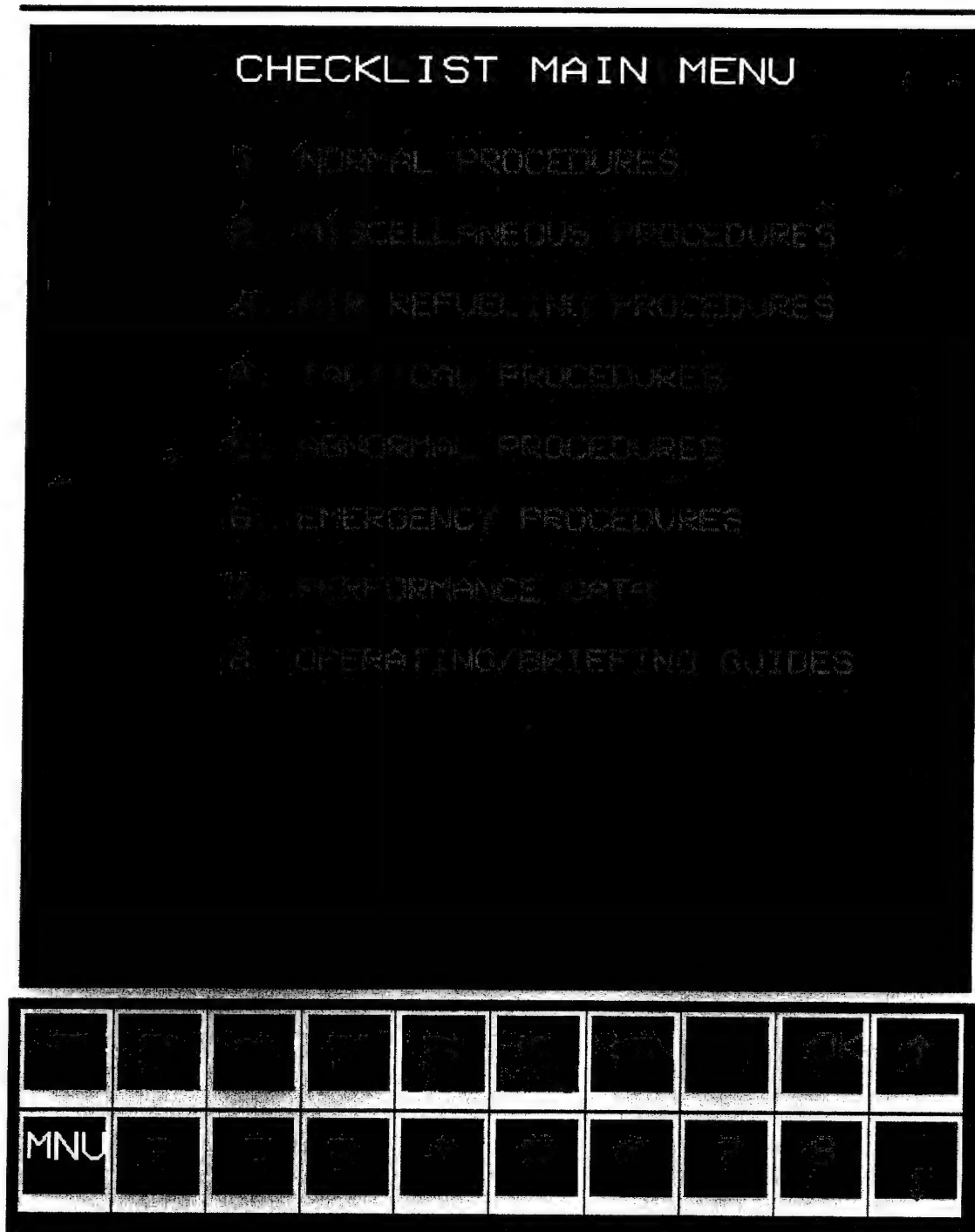


Figure A-7. Checklist Format. Main Menu Page.

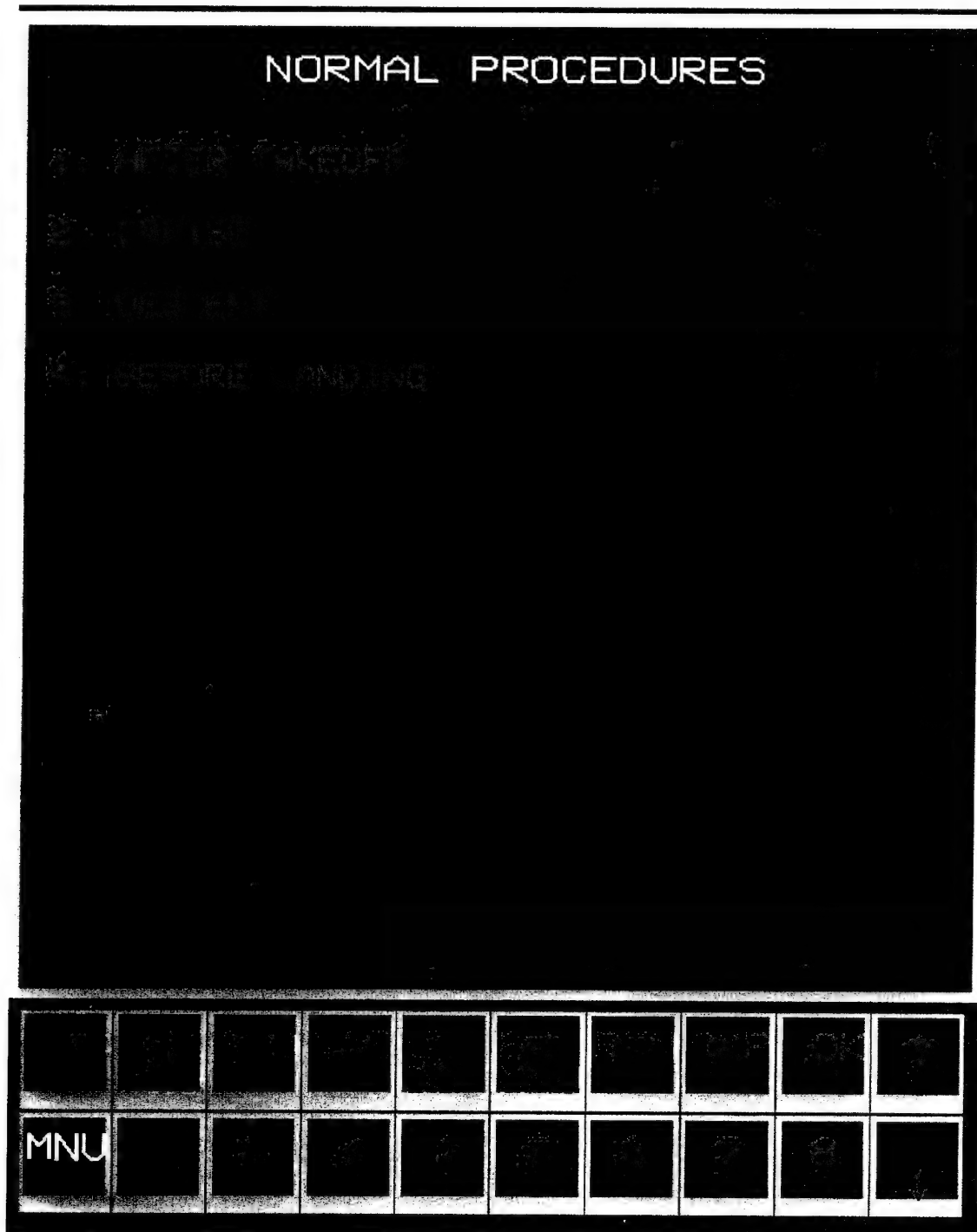


Figure A-8. Checklist Format. Sub Menu Page.

AFTER TAKEOFF		
1. Left Engine	OK	(CP)
2. Right Engine	OK	(CP)
3. Right Panel	OK	(CP)
4. Pressure Altitude	Check	(CP)
5. Fuel	OK	(CP)
6. Radar Alt	OK	(CP)
7. After Takeoff Checklist	Complete	(CP)

Figure A-9. Checklist Format. Sample Checklist Page.

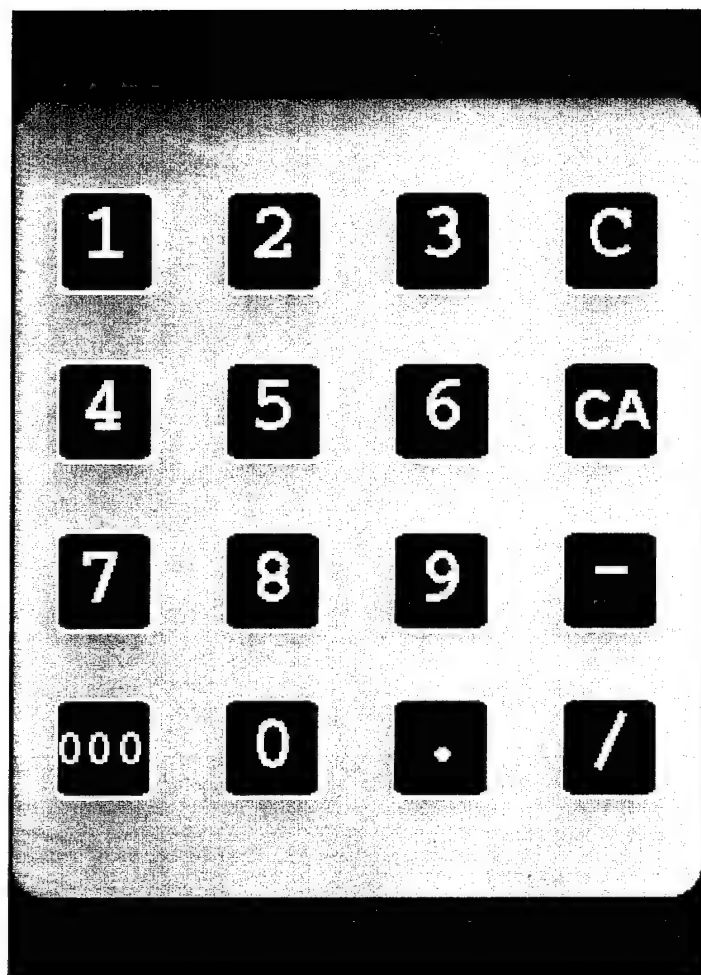


Figure A-10. Communication/Navigation Control Panel (CNCP) Alphanumeric Keypad.

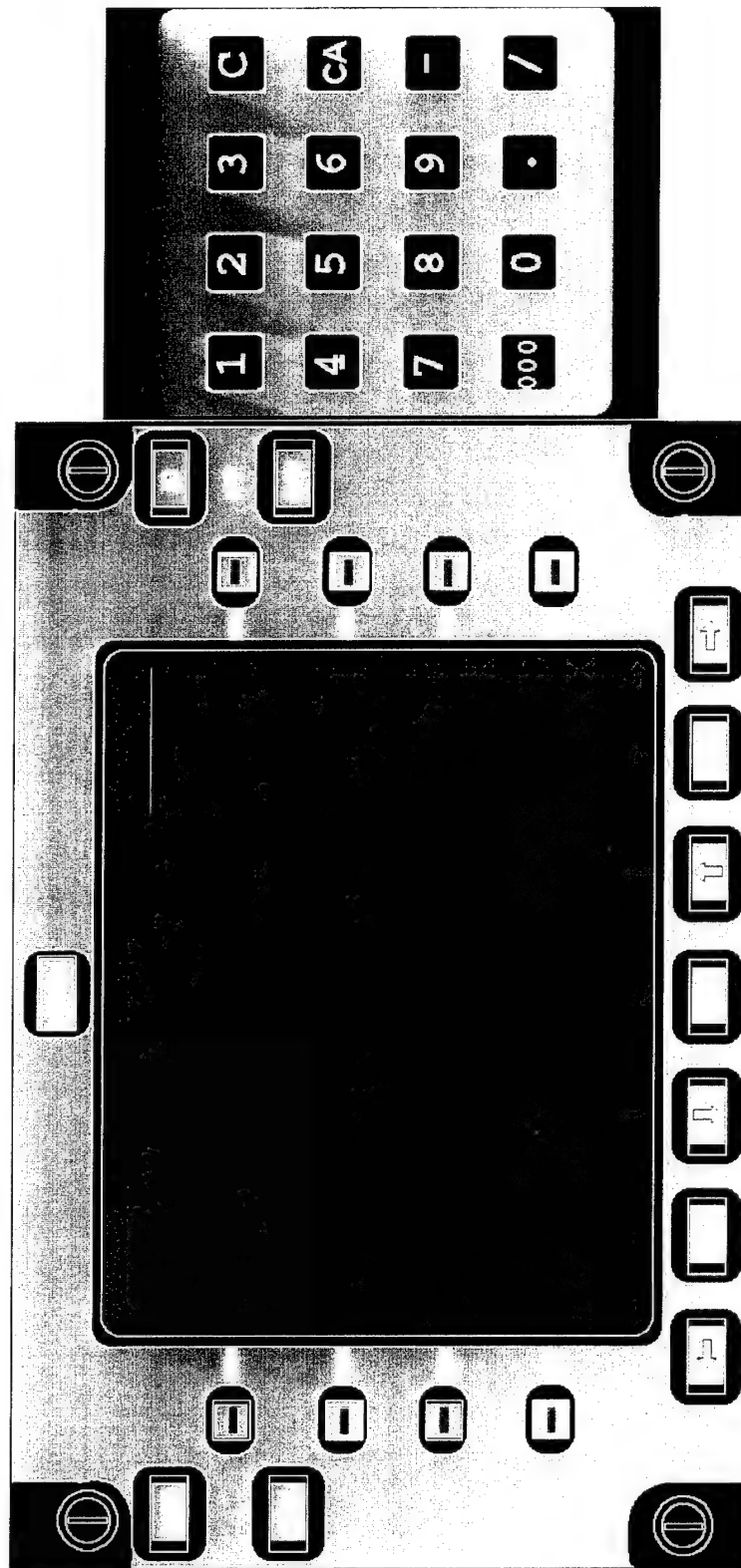


Figure A-11. Communication/Navigation Control Panel (CNC-P) Communication Format.

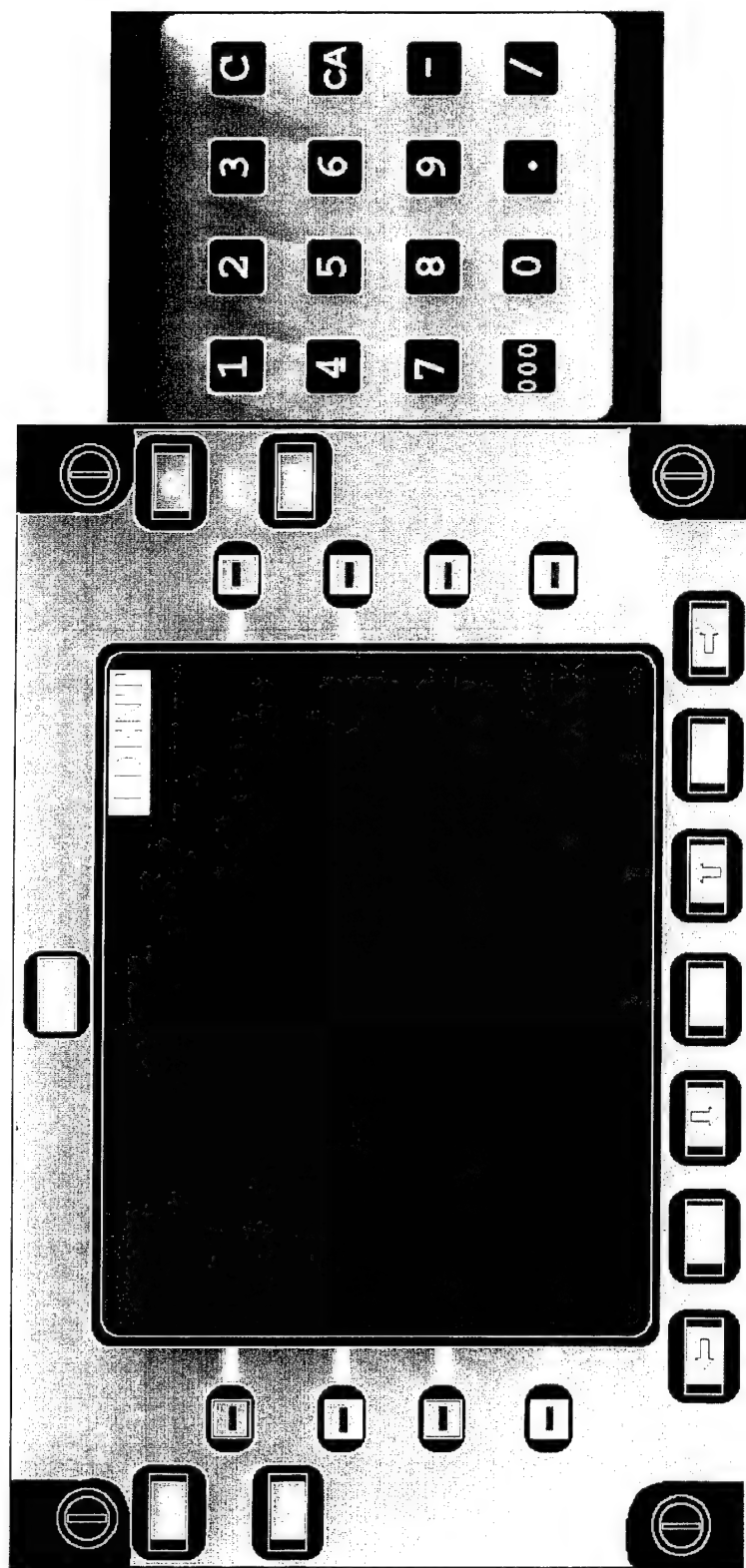


Figure A-12. Communication Navigation Control Panel (CCNP) Navigation Format Page 1.

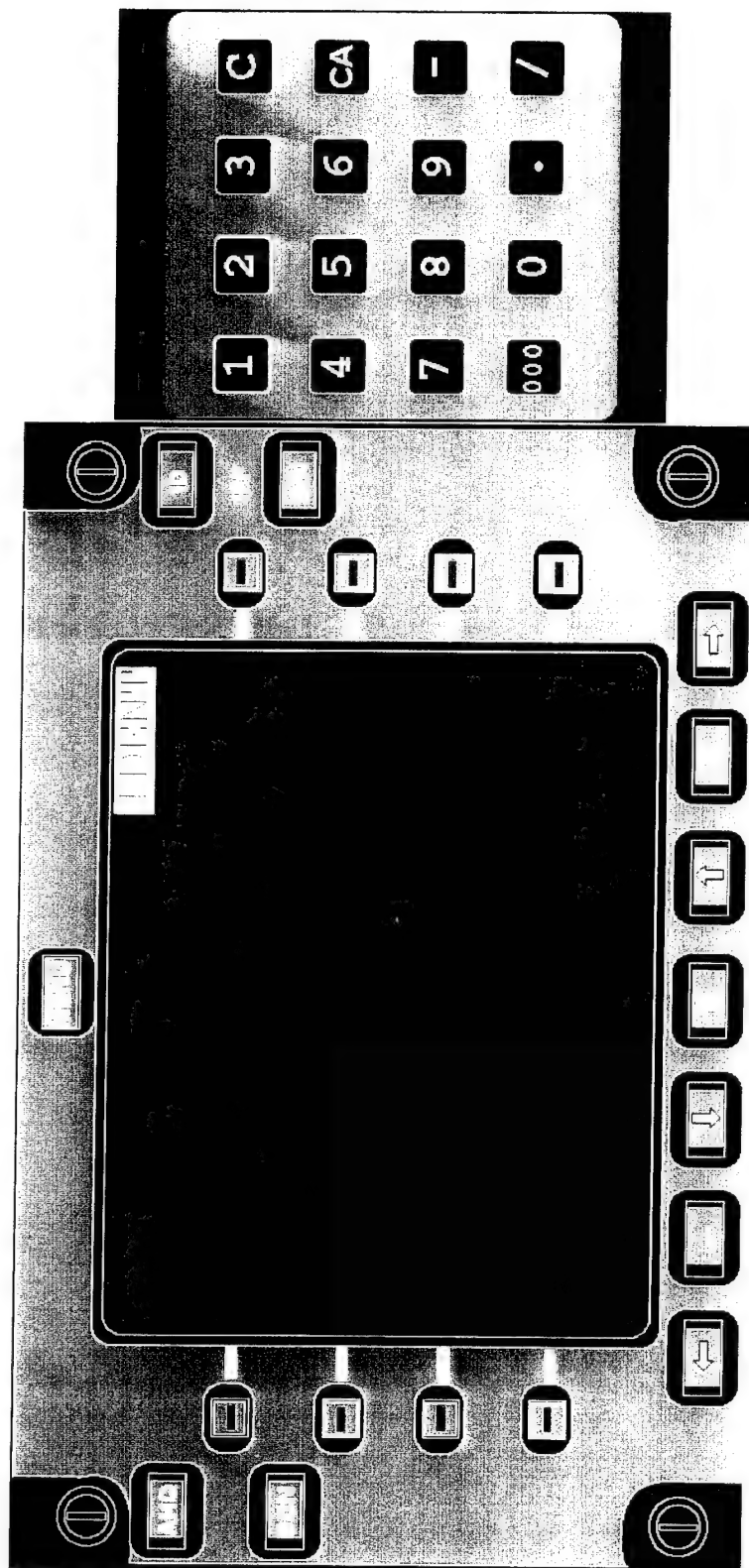


Figure A-13. Communication/Navigation Control Panel (CNC/P) Navigation Format Page 2.

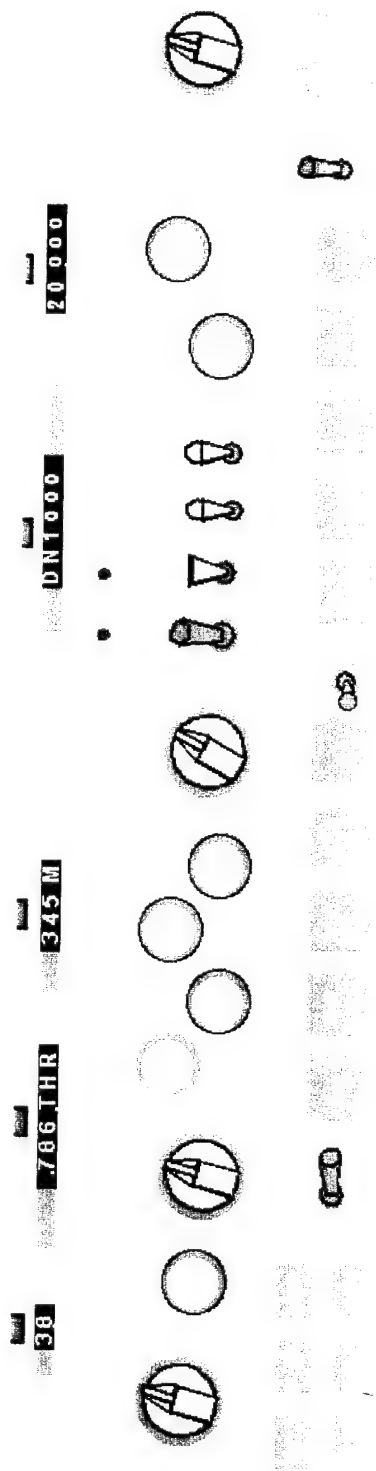


Figure A-14. Automatic Flight Control System (AFCS).

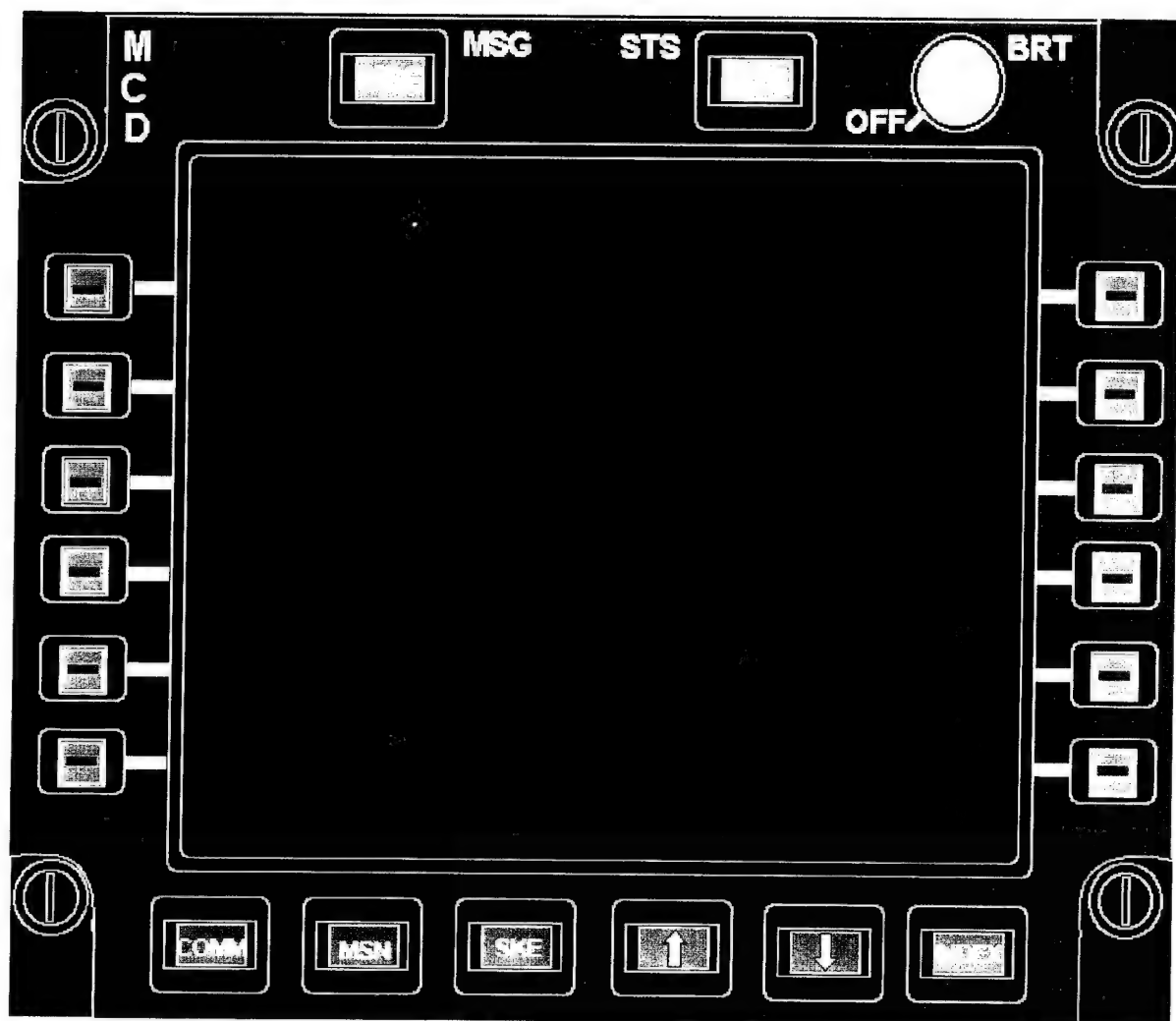


Figure A-15. Control Display Unit (CDU) Panel.

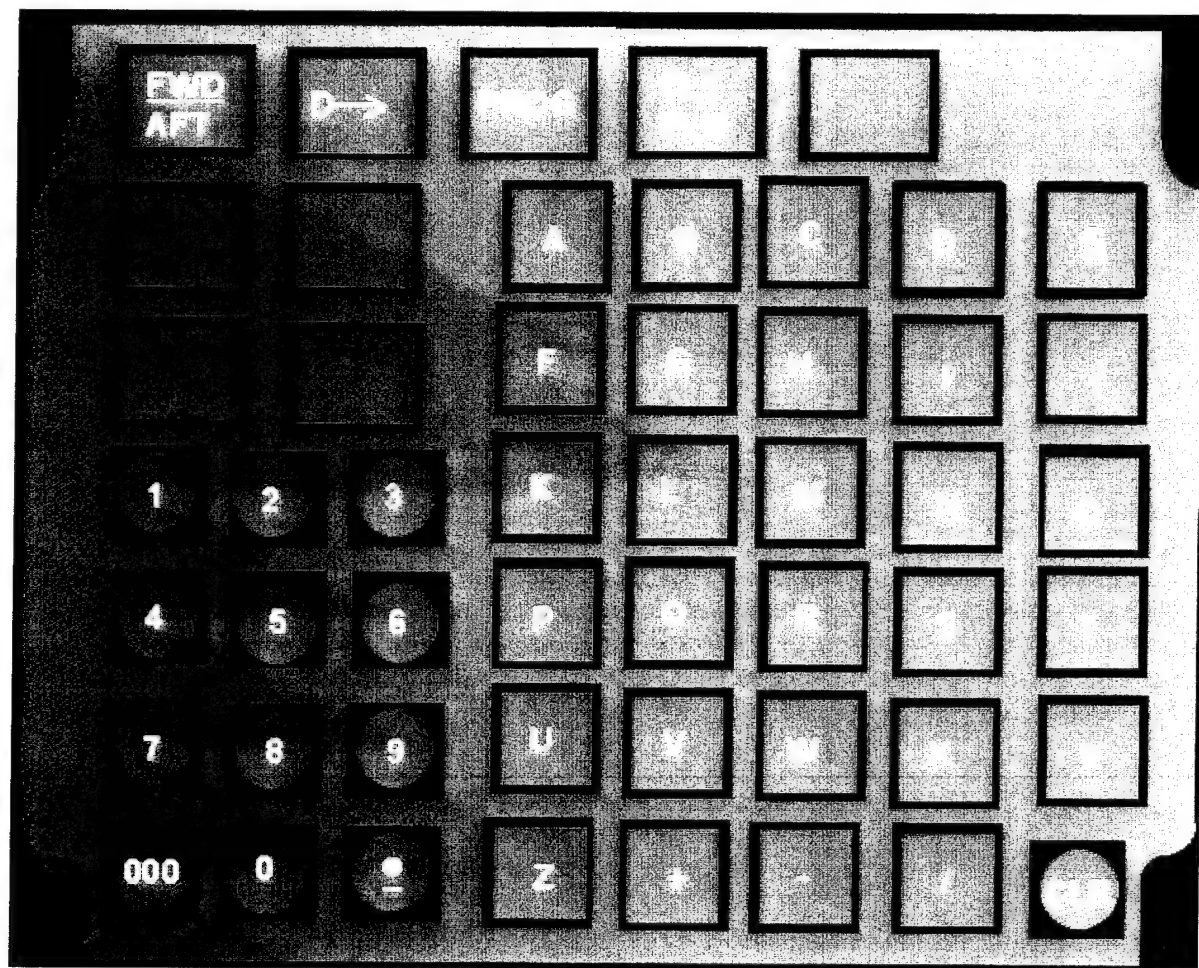


Figure A-16. Control Display Unit (CDU) Alphanumeric Keypad.

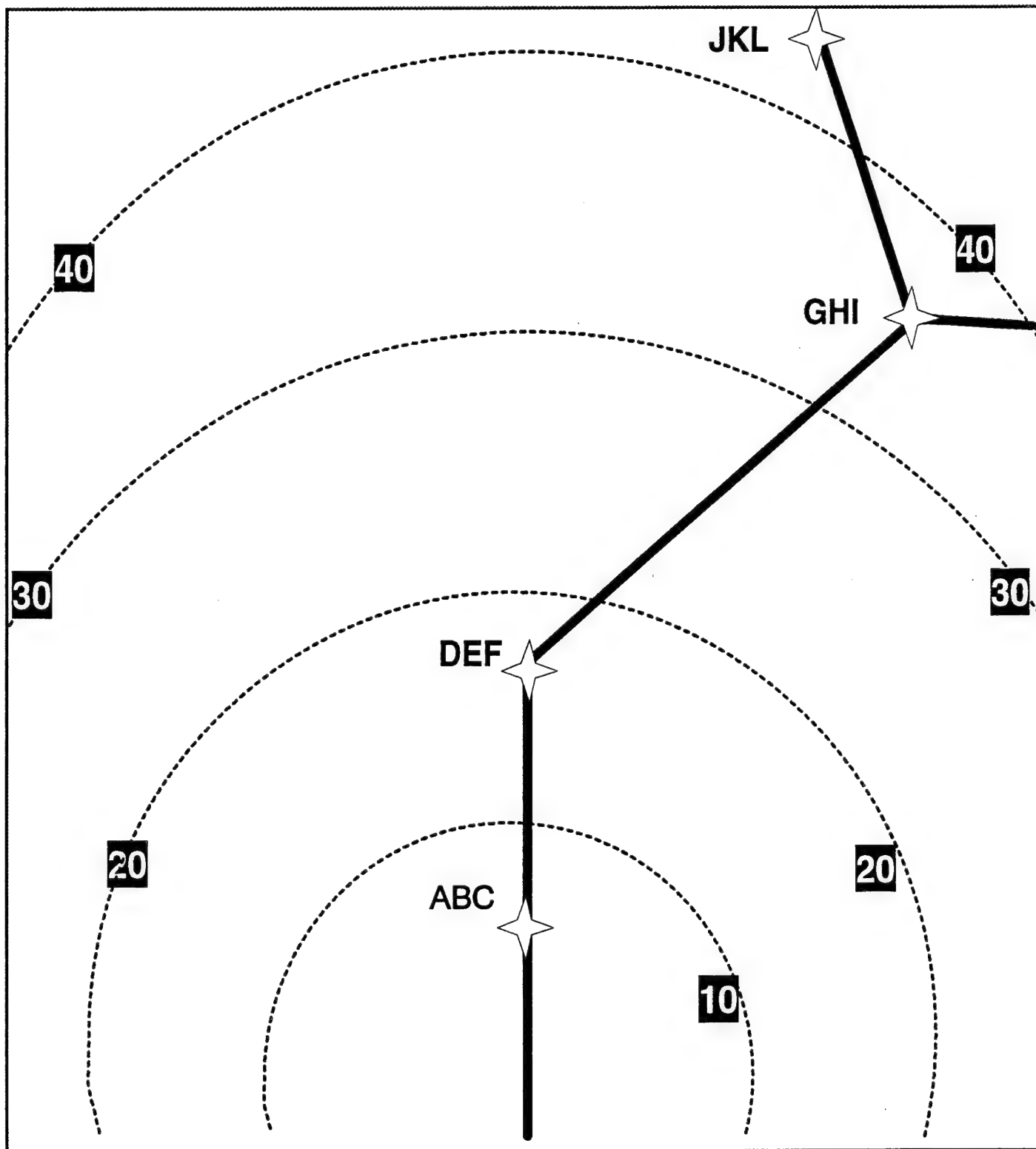


Figure A-17. Adding a waypoint. The original route.

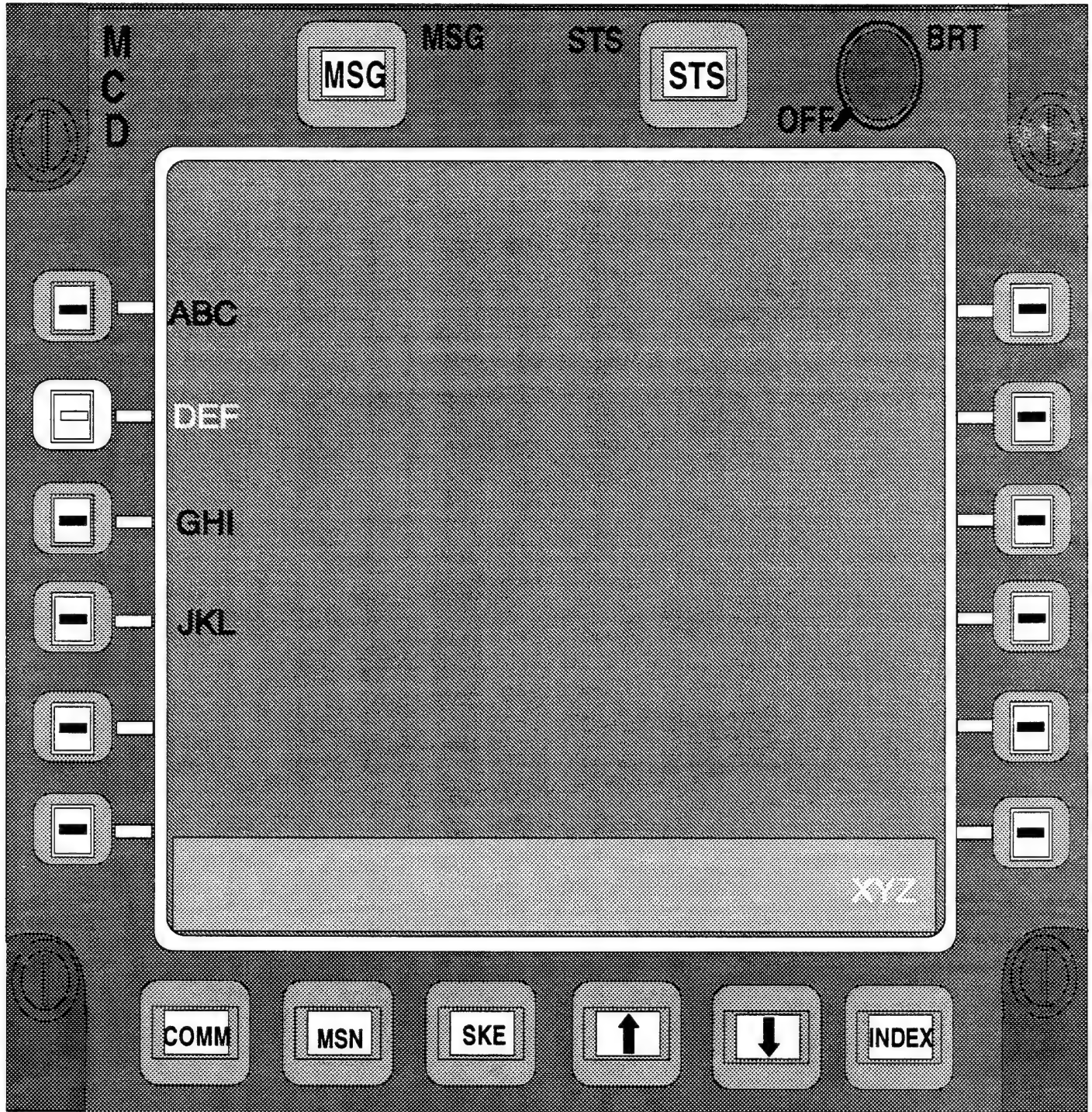


Figure A-18. Adding a waypoint. Enter new waypoint identifier on CDU.

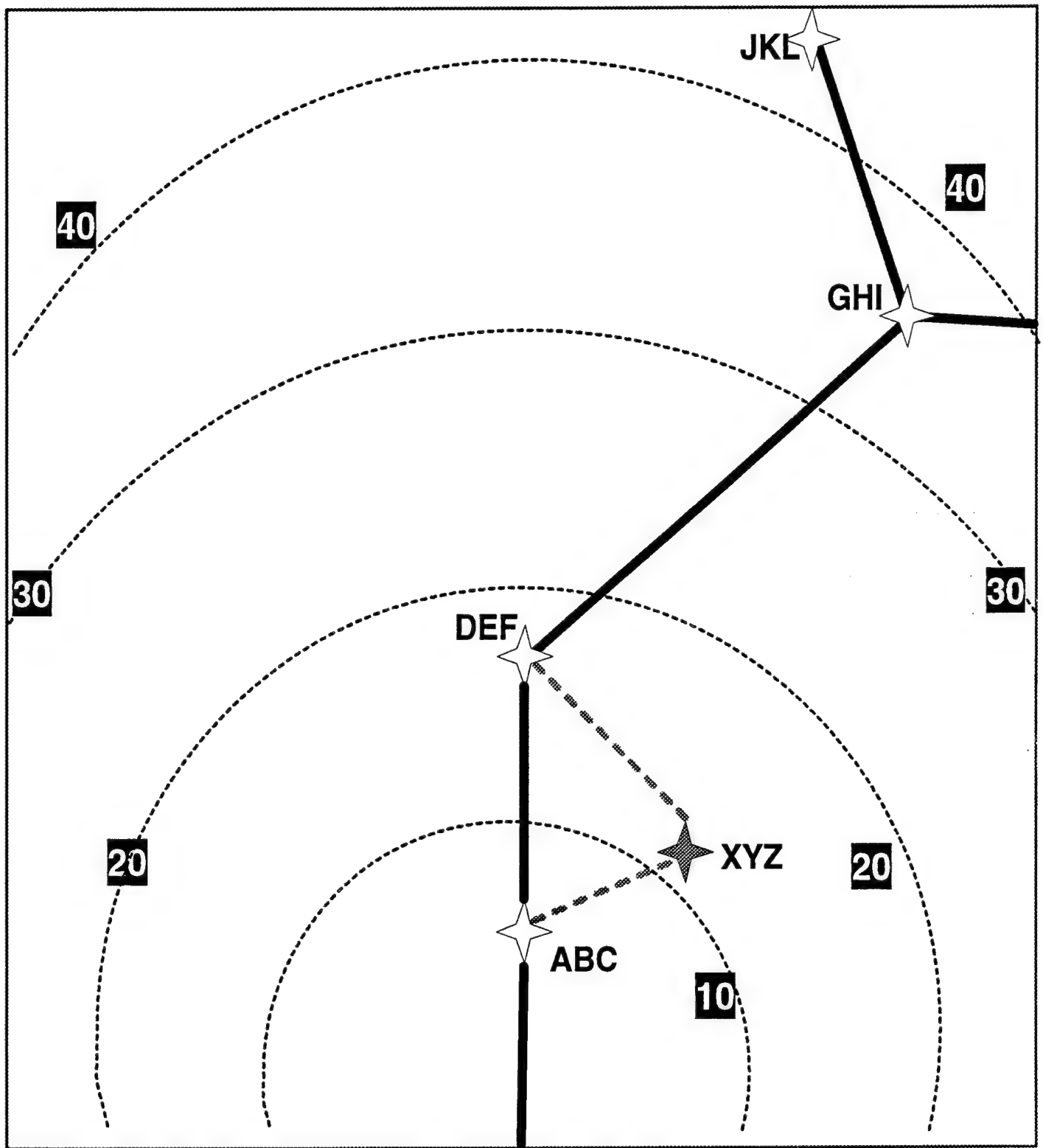


Figure A-19. Adding a waypoint. Result of change on HSF.

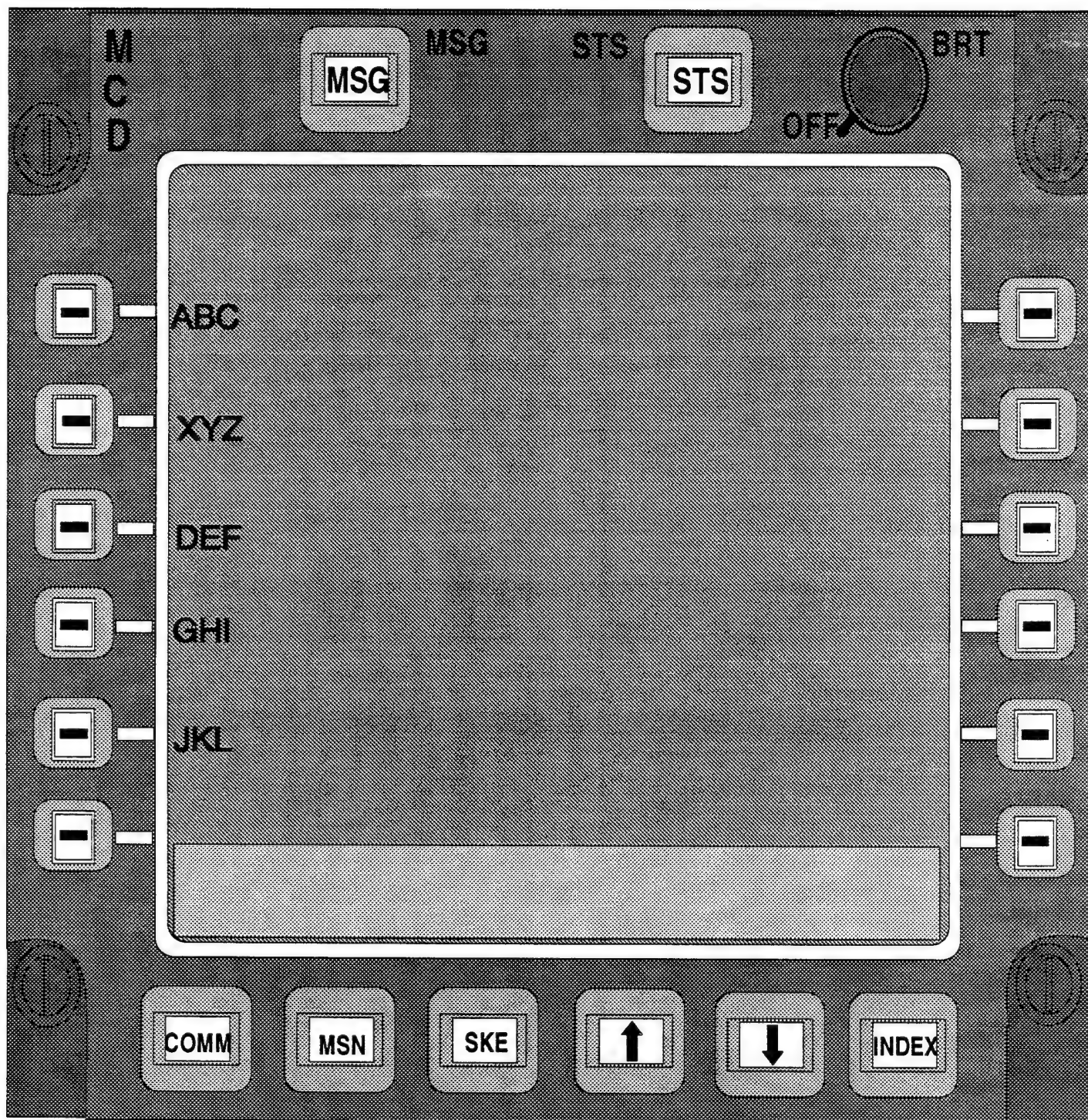


Figure A-20. Adding a waypoint. Result of change on CDU.

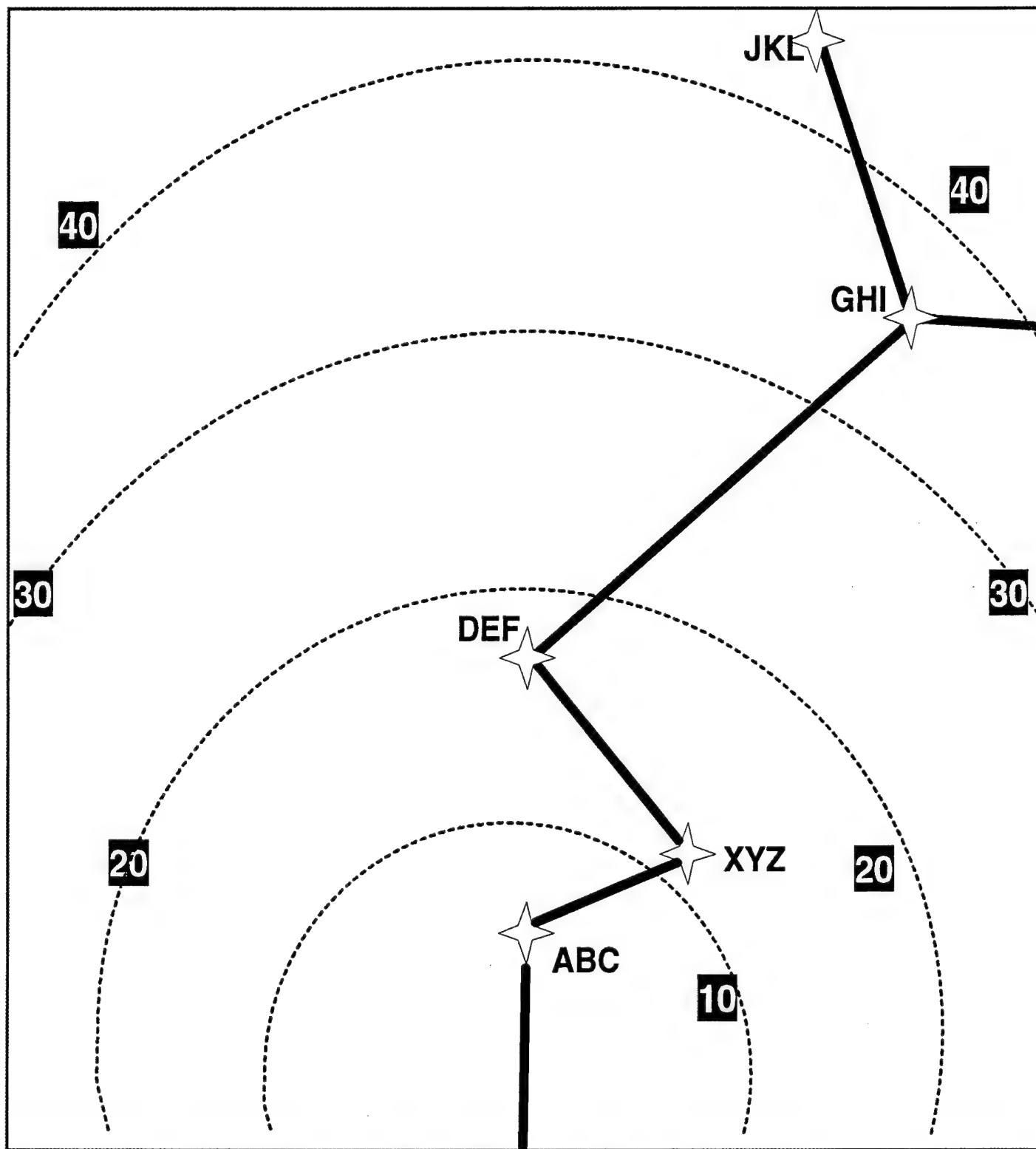


Figure A-21. Ammended route.

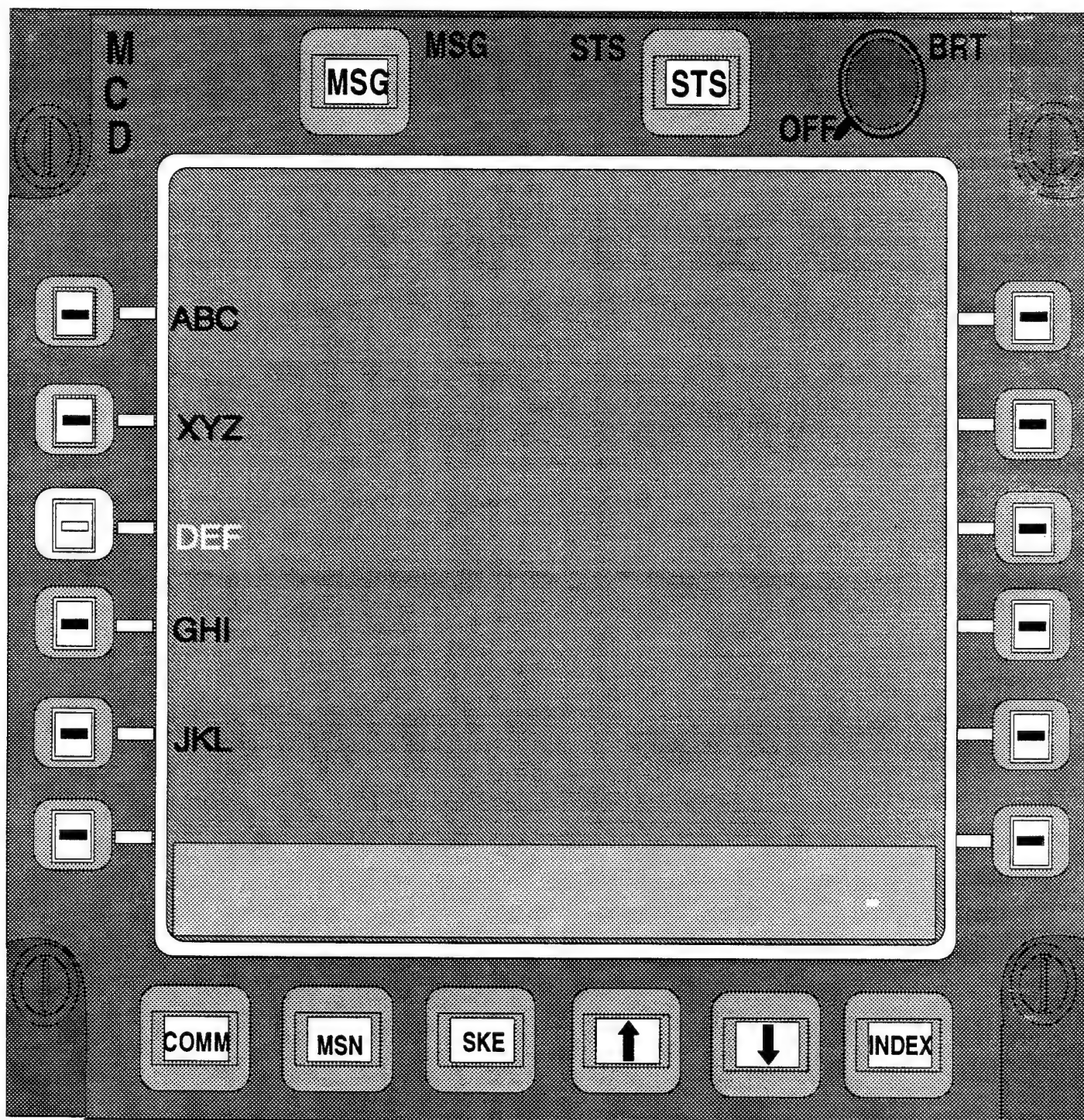


Figure A-22. Deleting a waypoint. Entering the change on CDU.

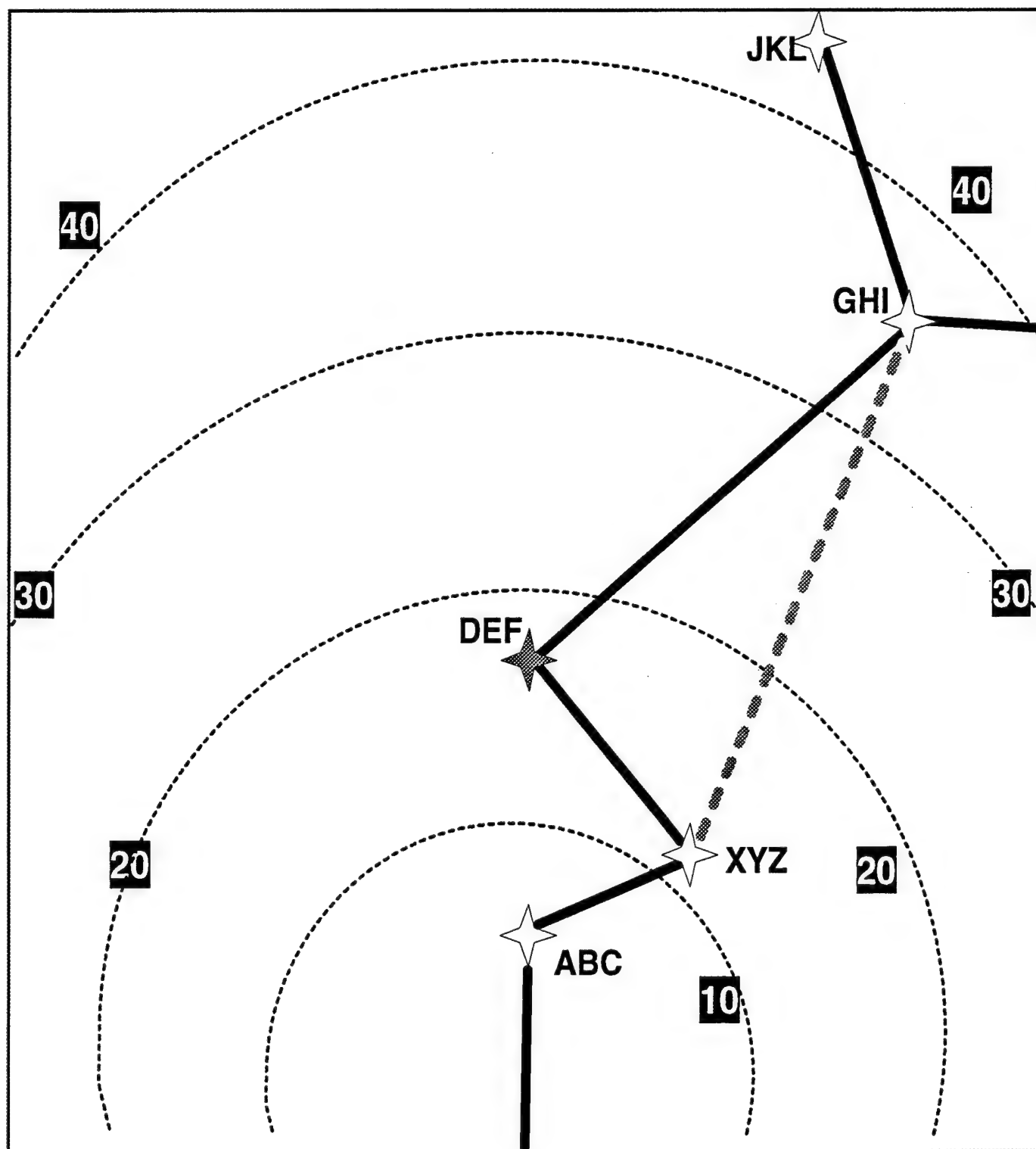


Figure A-23. Deleting a waypoint. Result of change on HSF.

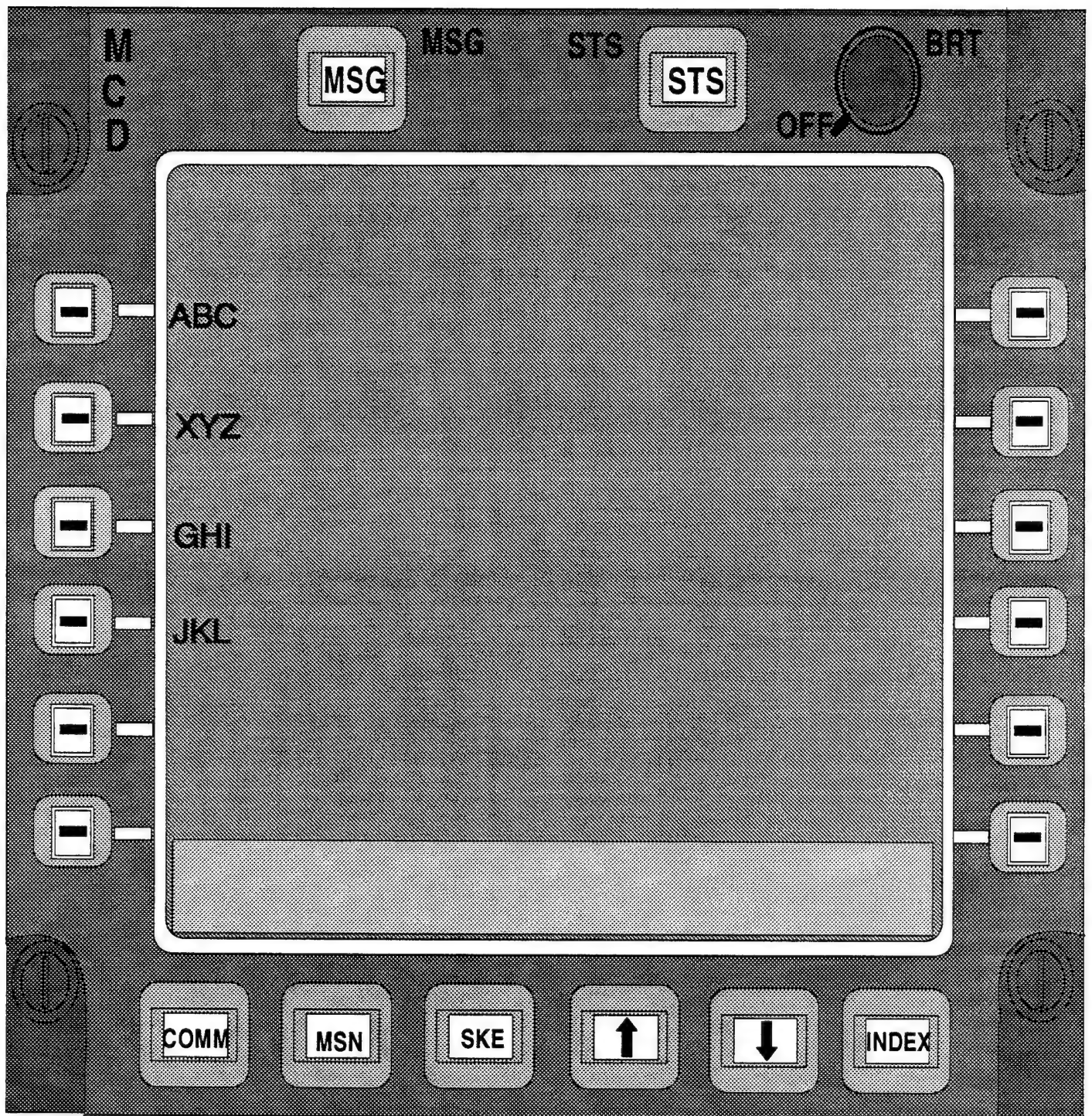


Figure A-24. Deleting a waypoint. Result of change on CDU.

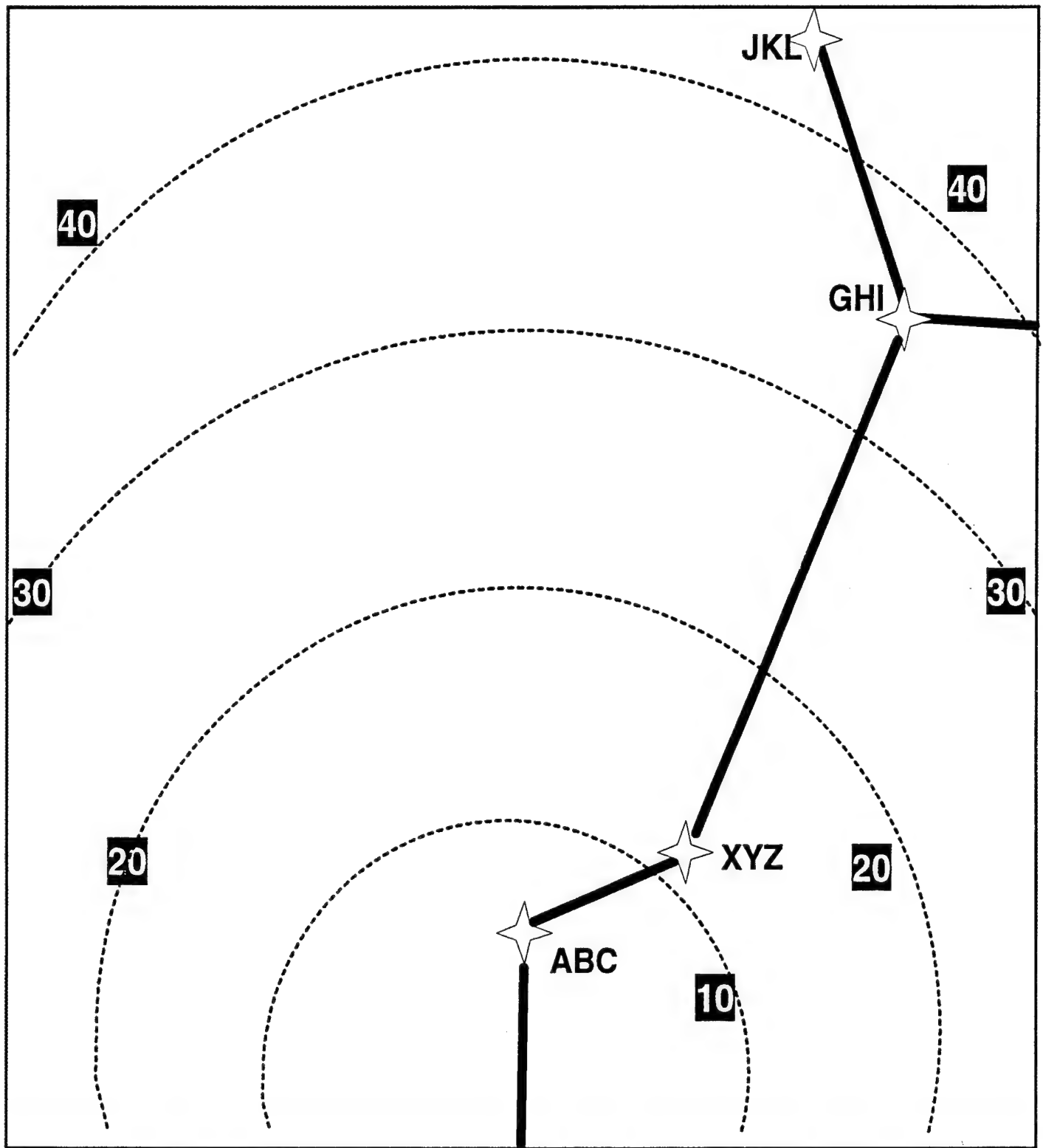


Figure A-25. The ammended route.

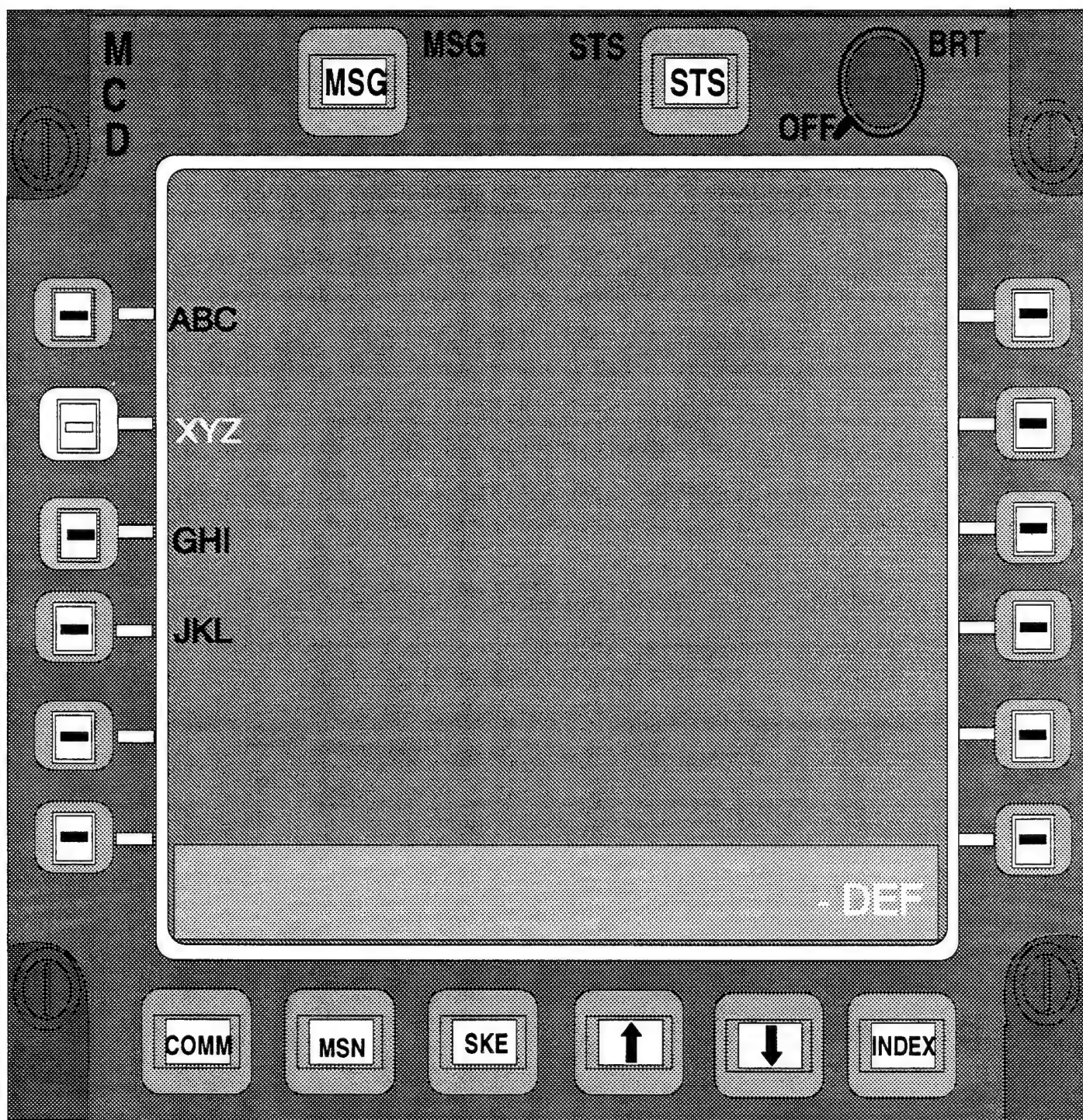


Figure A-26. Replacing a waypoint. Entering the change on CDU

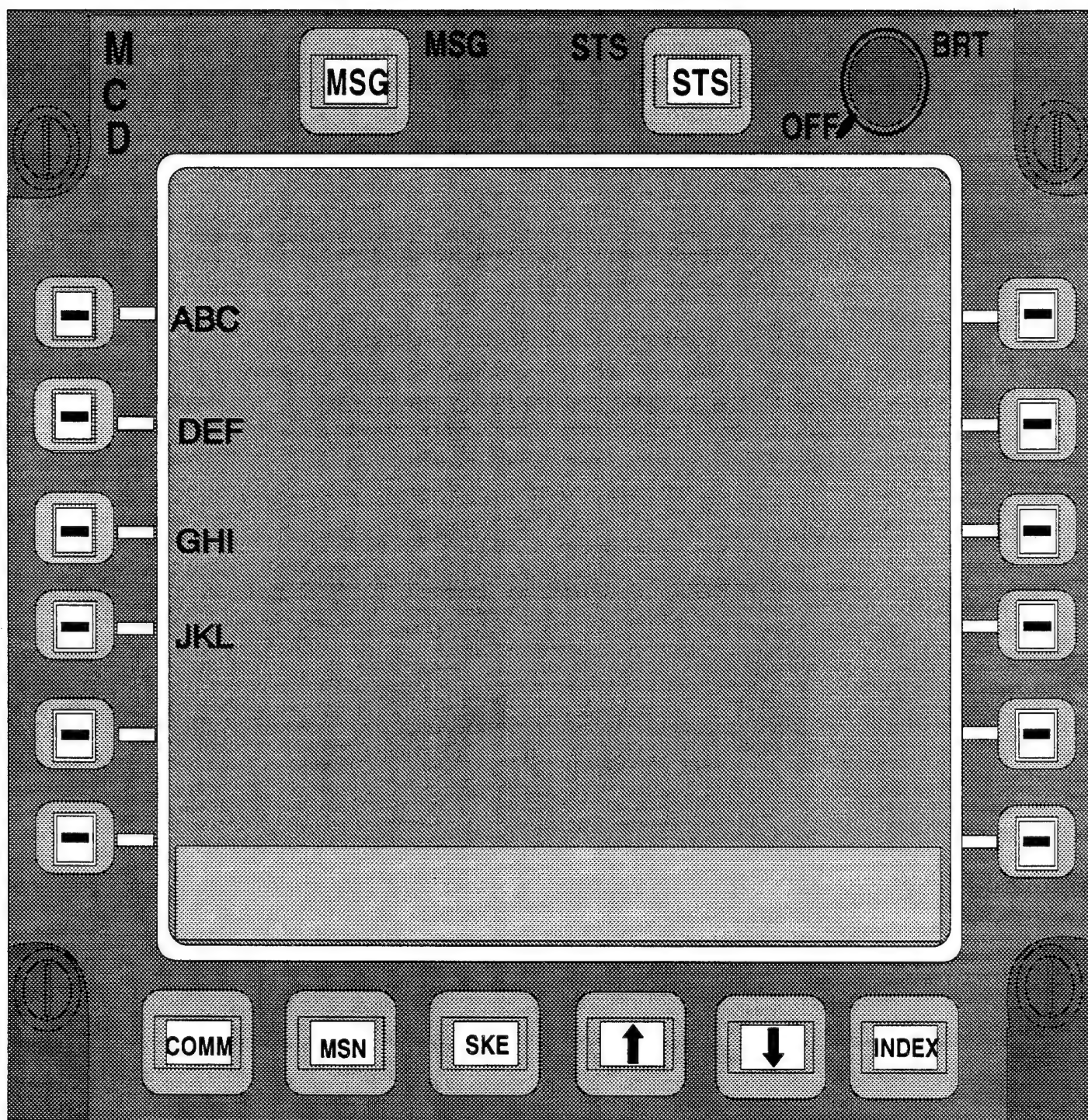


Figure A-28. Replacing a waypoint. Result of change on CDU.

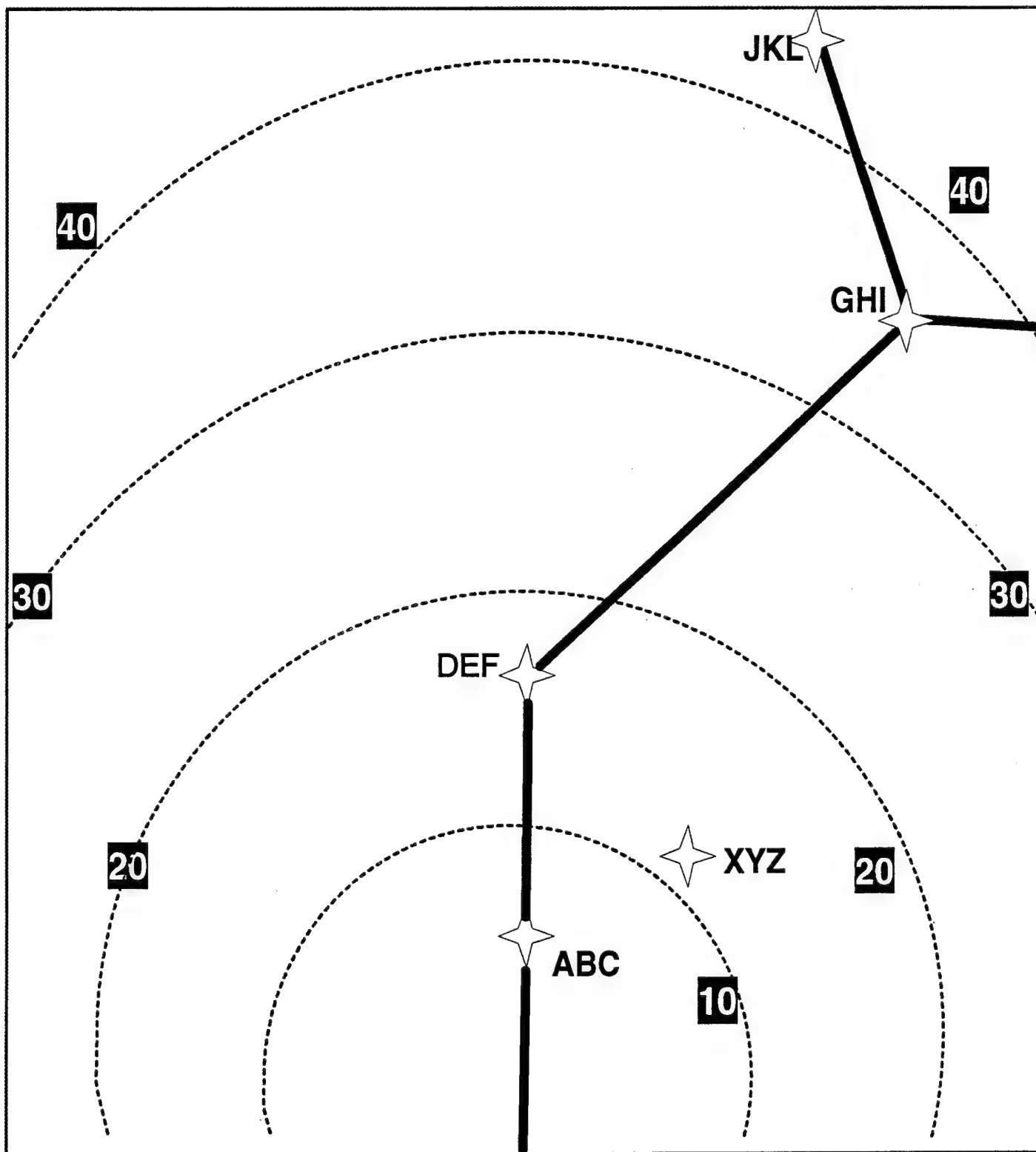


Figure A-29. The ammended route.

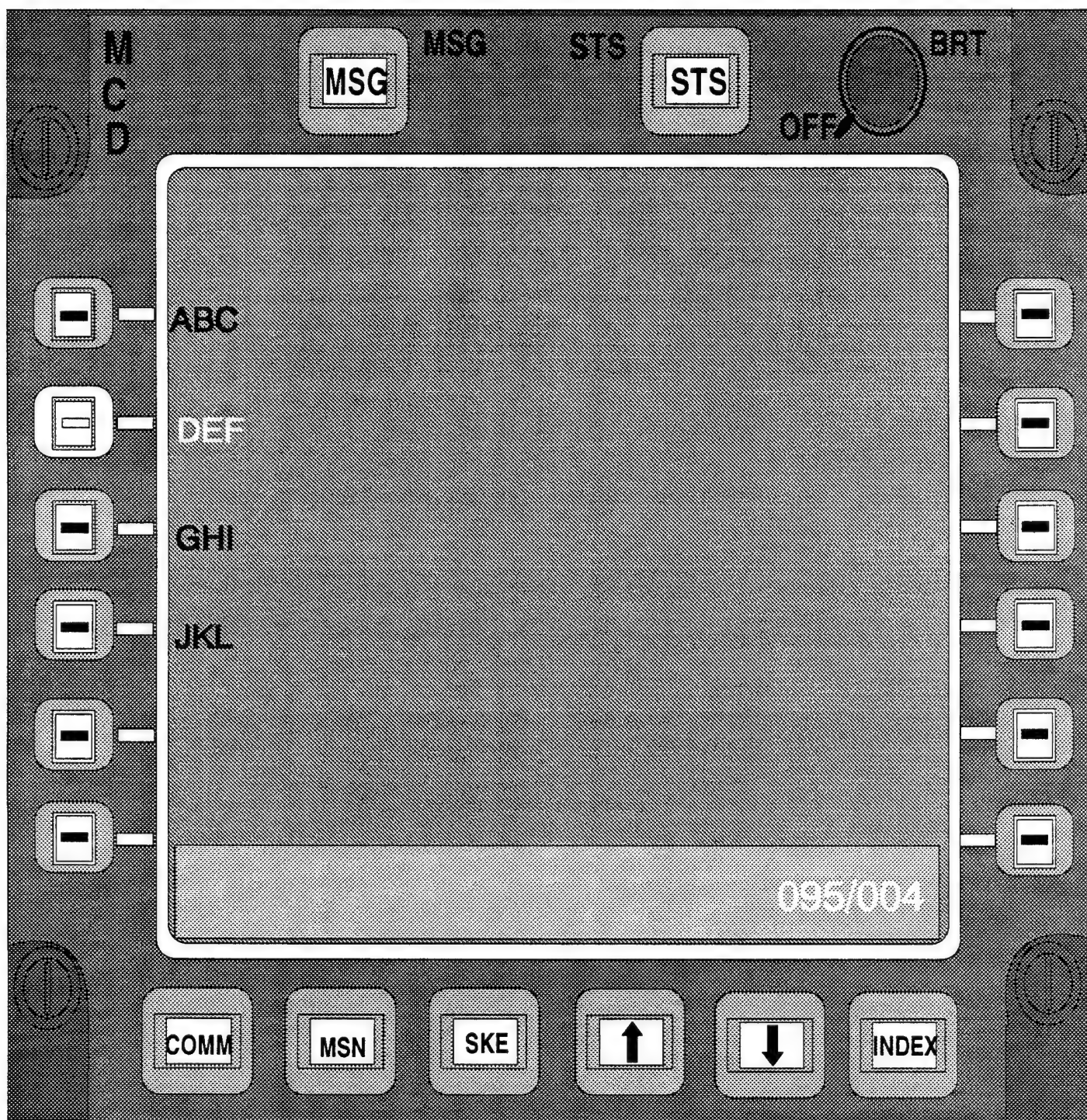


Figure A-30. Moving a waypoint. Enter bearing and distance on CDU.

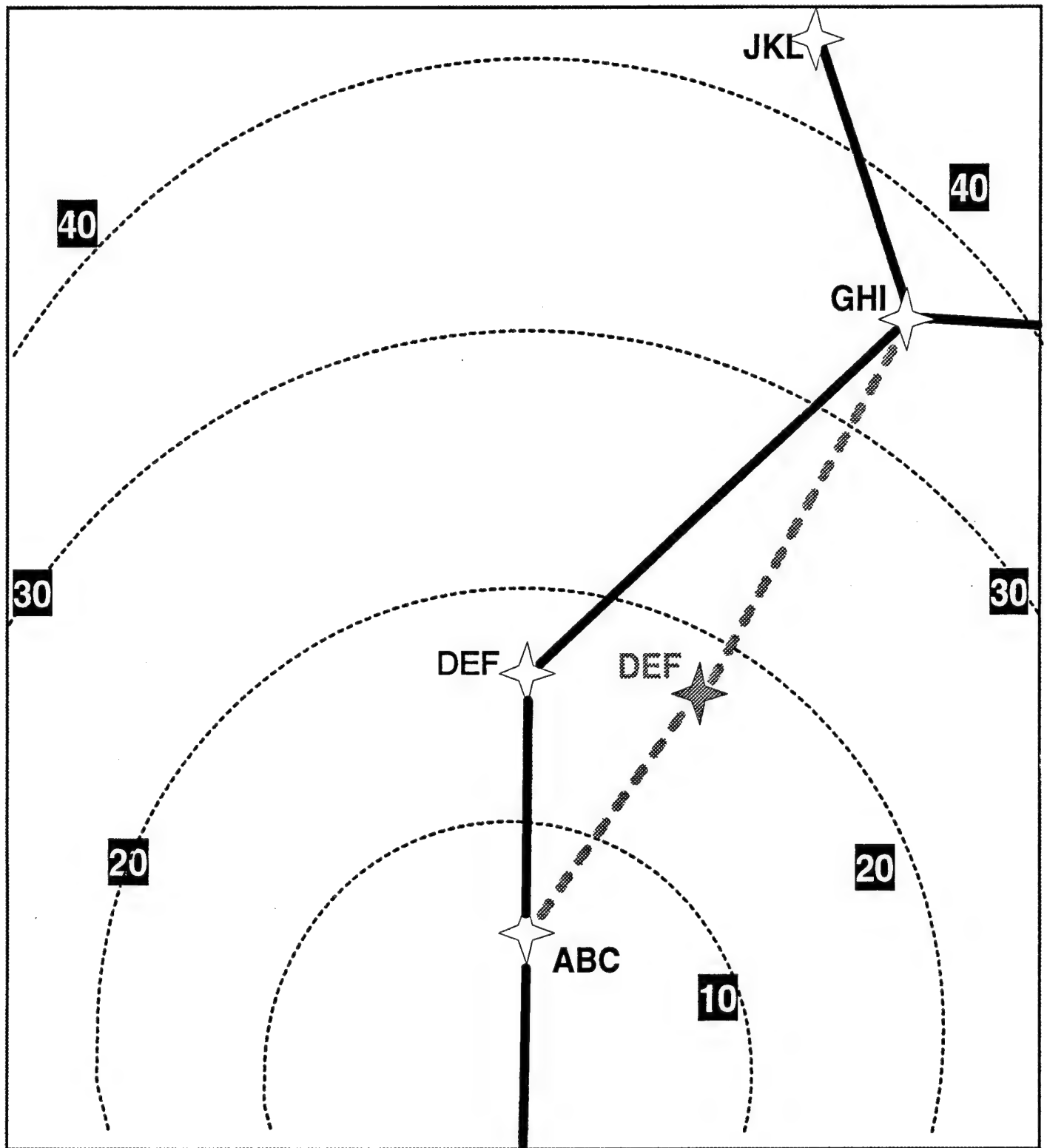


Figure A-31. Moving a waypoint. Result of change on HSF.

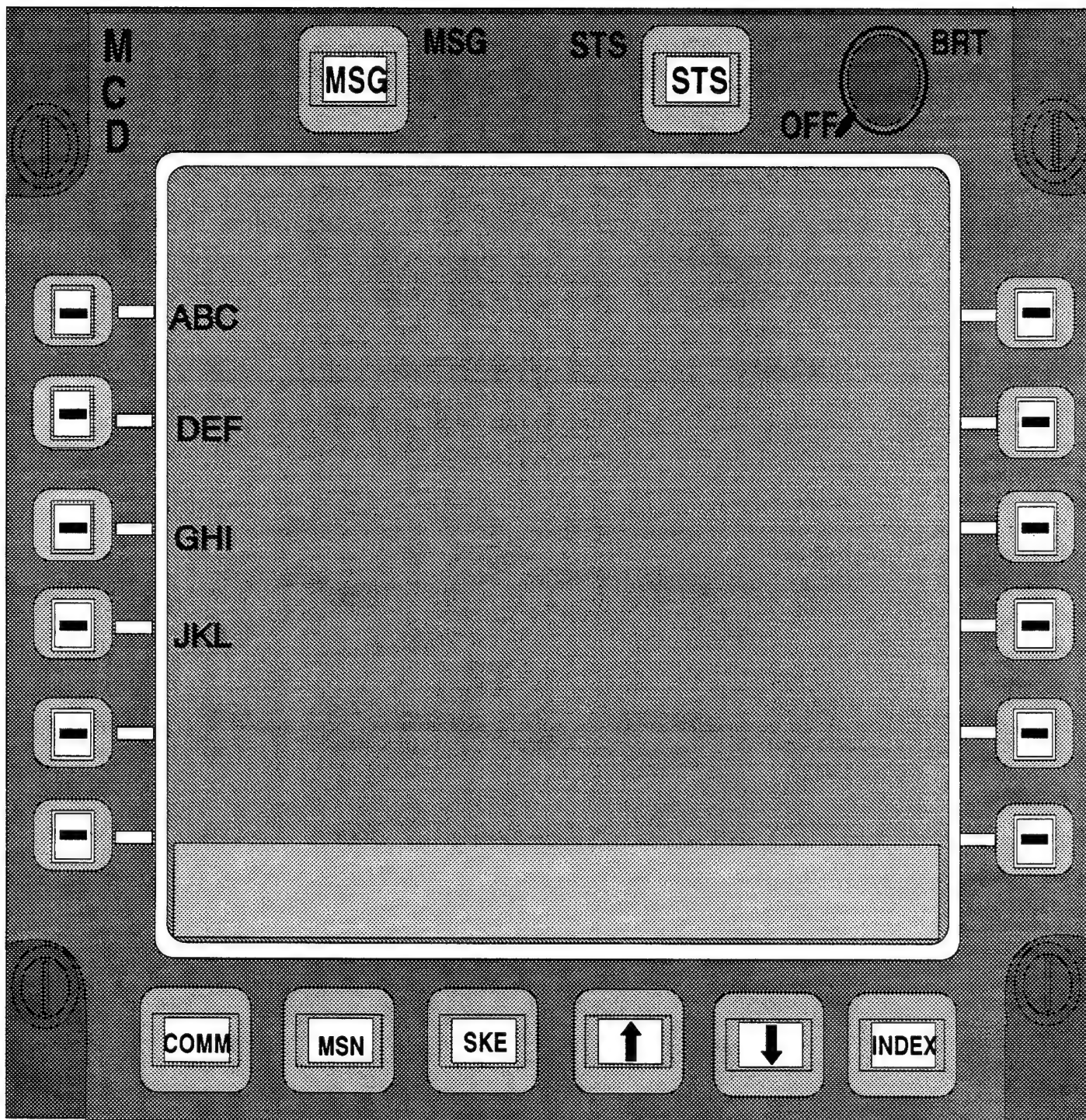


Figure A-32. Moving a waypoint. Result of change on CDU.

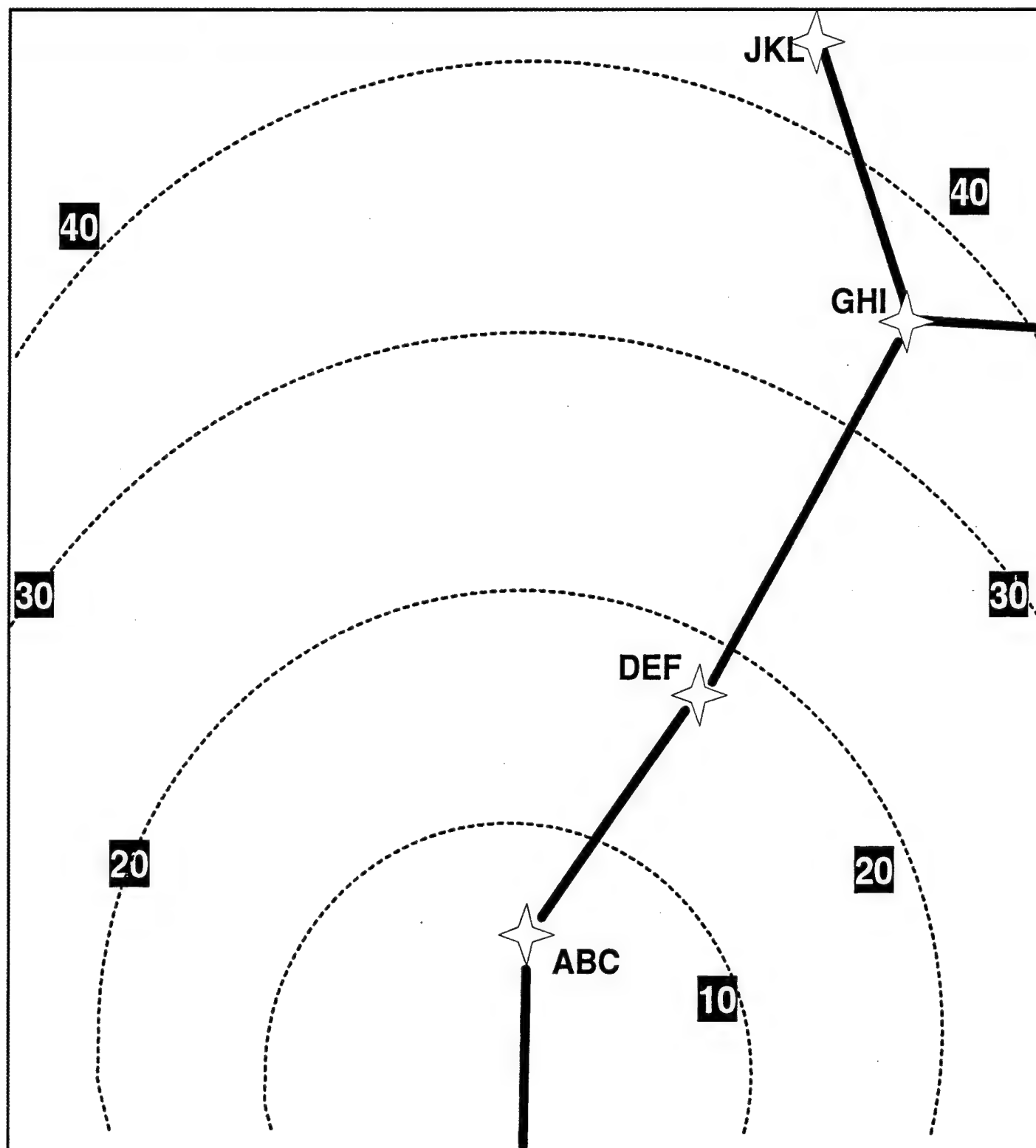


Figure A-33. The ammended route.

APPENDIX B
TRAINING MATERIALS AND SYLLABUS

TRAINING MATERIAL AND SYLLABUS

PURPOSE

This document provides an outline of the training discourse for the TRAC strategic demonstration. This guide has been developed to ensure a thorough and uniform training experience for each of the test crews. It is intended as a guide for the experimenter to follow in the training segments of each crew.

I. GROUND TRAINING

A. SESSION ONE: INTRODUCTION and ADMINISTRATION (1.0 HOUR)

1. Sign in
2. Schedule
3. Billeting/problems
4. Breaks/smoking/latrines/snacks/drinks
5. CSIL Facility
 - a. Entry/Exit
 - b. Emergency Procedures
 - c. Power switch locations
 - d. Fire extinguishers
6. Evaluation Process/Goals
 - a. Evaluating "Cockpit Design"
 - Not a Simulator Check Out
 - b. Overview of Evaluation
 - Training (handouts)
 - Evaluation Scenarios
 - Data Collection
 - SWAT Introduction
 - SWORD Introduction
 - Questionnaires Introduction
 - c. Debrief

B. SESSION TWO: COCKPIT FAMILIARIZATION (1.0 HOUR)

1. TRAC Entry/Exit
2. Pilots Side Shelf
 - a. ICS Box
 - b. Side-mounted Control Stick
3. Pilot's Seat/Rudder Pedals
 - a. Fore/Aft Adjust
 - b. Up/Down Adjust
 - c. Left/Right Adjust
 - e. Rudder Pedal Adjust
3. Pilot's Instrument Panel
 - a. HUD/OTW
 - b. CNCP and Keypad
 - c. Dual MFD's (CRT)
4. Center Instrument Panel
 - a. AFCS

- b. Center Dual MFD's (CRT)
 - c. Gear Lever/Indicators
 - d. Flap/Trim Indicators
- 5. Center Control Pedestal
 - a. CDUs (three each)
 - b. Throttle Quadrant
 - c. Flap Lever
 - d. ICS Box
- 6. Overhead Control Panel
 - a. Map Light Switch
 - b. Ceiling Light Switch
 - c. Control Loading Switch
 - d. Control Loading Emergency Shut-off
- 7. Co-Pilot's Instrument Panel
 - a. CNCP and Keypad
 - b. Dual MFD's (CRT)
- 8. Co-Pilot's Seat/Rudder Pedals
 - a. Fore/Aft Adjust
 - b. Up/Down Adjust
 - c. Left/Right Adjust
 - d. Arm Rest
 - e. Rudder Pedal Adjust
- 9. Co-Pilots Side Shelf
 - a. ICS Box
 - b. Side Control Stick
- 10. Simulator Operator's Console
 - a. IRIS Terminal
 - b. Map Light

C. SESSION THREE: CONTROL AND DISPLAY FAMILIARIZATION (1.0 HOUR)

- 1. OTW/HUD
 - a. Symbolology
 - b. Controls
 - c. Function
- 2. MFDs (Five Formats)
 - a. PFD- symbolology, controls, function
 - b. HSF- symbolology, controls, function
 - c. PVU- "
 - d. ENG- "
 - e. CHK- "
- 3. CNCPs
 - a. Communication- controls and function
 - b. Navigation- controls and function
- 4. AFCS
 - a. heading, airspeed, altitude selection
 - b. NAVAID selection
 - c. Auto Pilot engagement
 - heading hold
 - airspeed hold
 - altitude hold
 - LNAV, VNAV
 - d. pilot ID

5. CDUs
 - a. Flight plan menu
 - adding, moving, deleting way points
 - b. Direct to menu
6. ICS Boxes
 - a. control and function
7. Throttle Quadrant/Flap lever/Flight Controls
 - a. Indicators
 - b. Controls

D. SESSION FOUR: CONTROL AND DISPLAY EXERCISE (2.0 HOURS)

1. MFDs
 - a. Select Various Displays
 - PFD, HSF, PVU, ENG, CHK
 - b. Select all PDP options per each display
2. CNCs
 - a. Select between comm and nav menu pages
 - Enter/change comm/nav frequencies/courses
 - Enter/change IFF codes
 - Select/deselect primary comm/nav radio
3. AFCS
 - a. Set Altitude reference marker
 - b. Set Airspeed reference marker
 - c. Select primary navaid
 - d. Engage Autopilot
 - Set heading hold
 - Set altitude hold
 - Set airspeed hold
 - Set LNAV/VNAV
 - e. Command autopilot to pilot navaid reference
 - f. Command autopilot to co-pilot navaid reference
4. CDUs
 - a. Call up Flight Plan Menu Page
 - Add way point
 - Delete way point
 - Change way point location
 - Add radial/DME fix
 - b. Call up Direct To menu page
 - select fly direct to way point
5. Throttle Quadrant/Flap lever/Flight Controls
 - a. Locate gear, flap and trim indicators
 - actuate gear, flap, and trim controls

II. FLIGHT TRAINING

A. SESSION ONE: BASIC FLIGHT MANEUVERS (3 HOURS)

1. Pre brief/Preflight
 - a. Simulator safety
 - b. Maneuvers description

- c. Systems/Display set up
- 2. Basic Aircraft Control (HUD)
 - a. Airspeed/Altitude/Heading changes
 - b. Confidence maneuvers
 - c. Unusual attitudes
- 3. Basic Aircraft Control (Instruments)
 - a. Airspeed/Altitude/Heading changes
 - b. Confidence maneuvers
 - c. Unusual attitudes

B. SESSION TWO: ADVANCED FLIGHT MANEUVERS (3 HOURS)

- 1. Pre brief/Preflight
 - a. Maneuvers description
 - b. Systems/Display set up
- 2. Navigation
 - a. Course intercept
 - b. Airway route flight
 - c. Mission computer (direct) route flight
- 3. Instrument Approach
 - a. Precision
 - b. Non-precision
- 4. Landings
 - a. Touch and go
 - b. Full stop

TRAC SIMULATOR TRAINING SYLLABUS FORM

I. GROUND TRAINING	Knowledge	Performance
A. MULTIFUNCTION DISPLAYS		
1. PRIMARY FLIGHT DISPLAYS (PFD)		
a. EADI		
b. EHSI		
c. PDPs		
2. HORIZONTAL SITUATION FORMAT (HSF)		
a. HSF SYMBOLOGY		
b. PDPs		
3. ENGINE DISPLAYS (PVU and ENG)		
a. ENGINE DISPLAY SYMBOLOGY		
b. PDPs		
4. CHECKLIST DISPLAY (CHK)		
a. CHECKLIST DISPLAY FORMAT		
b. PDPs		
5. HEAD-UP DISPLAY (HUD)		
a. HUD DISPLAY SYMBOLOGY		
B. COMMUNICATION/NAVIGATION CONTROLS		
1. COMMUNICATION MENU PAGE		
a. COMM PAGE FORMAT		
b. KEYPAD OPERATION		
c. LSK OPERATION		
2. NAVIGATION MENU PAGE		
a. NAV PAGE FORMAT		
b. KEYPAD OPERATION		
c. LSK OPERATION		
C. CONTROL DISPLAY UNIT (CDU)		
1. MAIN MENU PAGE		
a. MAIN PAGE FORMAT		
b. KEYPAD OPERATION		
c. LSK OPERATION		
2. FLIGHT PLAN MENU PAGE		
a. FLIGHT PLAN PAGE FORMAT		
b. KEYPAD OPERATION		
c. LSK OPERATION		

TRAC SIMULATOR TRAINING SYLLABUS FORM

I. GROUND TRAINING (CONT.)	Knowledge	Performance
3. DIRECT-TO MENU PAGE		
a. DIRECT-TO PAGE FORMAT		
b. LSK OPERATION		
4. COMMUNICATIONS MENU PAGE		
a. COMM PAGE FORMAT		
b. KEYPAD OPERATION		
c. LSK OPERATION		
D. AUTOMATIC FLIGHT CONTROL SYSTEM		
1. NAV/MSN COMPUTER AREA		
a. PILOT NAV SELECT		
b. CO-PILOT NAV SELECT		
2. THRUST VELOCITY AREA		
a. REFERENCE AIRSPEED SELECT		
b. AIRSPEED HOLD SELECT		
3. ROLL CONTROL AREA		
a. HEADING HOLD SELECT		
b. LNAV SELECT		
4. PITCH CONTROL AREA		
a. ALTITUDE HOLD SELECT		
b. VNAV SELECT		
5. AFCS CONTROL AREA		
a. ATS SELECT		
b. AP SELECT		
c. PILOT ID SELECT		
E. PRIMARY/SECONDARY CONTROL SURFACE		
1. PRIMARY CONTROL SURFACES		
a. ELEVATOR		
b. AILERON		
c. RUDDER		
2. SECONDARY CONTROL SURFACES		
a. TRIM TABS		
b. FLAPS		
c. SPOILERS		
d. SLATS		
3. MISCELLANEOUS		
a. GEAR		

TRAC SIMULATOR TRAINING SYLLABUS FORM

II. FLYING TRAINING	Knowledge	Performance
A. PREFLIGHT		
1. COMM EQUIPMENT		
2. NAV EQUIPMENT		
3. MULTIFUNCTION DISPLAYS		
4. AUTOPILOT SYSTEM		
5. SEAT AND RUDDER ADJUSTMENTS		
B. BASIC AIRCRAFT CONTROL		
1. LEVEL FLIGHT		
a. AIRSPEED		
b. ALTITUDE		
c. HEADING		
2. STEEP TURNS		
a. AIRSPEED		
b. ALTITUDE		
c. HEADING		
3. VERTICAL "S"s		
a. ALPHA		
b. BRAVO		
c. CHARLIE		
d. DELTA		
4. AIRSPEED CHANGES		
a. LEVEL FLIGHT		
b. TURNING		
c. CLIMBING/DESCENDING		
5. NAVIGATION		
a. SET/SELECT NAVAID COURSE		
b. COURSE INTERCEPT		
c. MAINTAINING COURSE		
6. INSTRUMENT PROCEDURES		
a. ARCING		
b. HOLDING		
c. NON-PRECISION APPROACH		
d. PRECISION APPROACH		
7. LANDINGS		
a. TOUCH AND GO		
b. FULL STOP		

APPENDIX C
STRATEGIC MISSION SCRIPTS

MISSION #1

Mission start point will be overhead KPOB (Pope AFB) at 2000'. Crew has just completed touch and go land and is awaiting clearance from tower for round robin training.

TOWER CONTROLLER: TRAC zero one, Pope Tower.

TRAC ZERO ONE: Responds.

TOWER CONTROLLER: TRAC zero one, clearance available, advise when ready to copy.

TRAC ZERO ONE: Acknowledges ready to copy.

TOWER CONTROLLER: TRAC zero one is cleared to Pope, on climb-out turn left heading one two zero (120) intercept the Fayetteville three three five radial (335R) then as filed, climb and maintain eight thousand (8000 ft), contact departure control on one three three point zero or two nine five point zero (133.0/295.0) squawk three five zero one, advise when ready to depart.

TRAC ZERO ONE: Reads back.

TRAC ZERO ONE: Advises ready to depart

TOWER CONTROLLER: TRAC zero one, contact departure control, Good Day.

TRAC ZERO ONE: Acknowledges. (changes radio frequencies to depart)

TRAC ZERO ONE: Contacts Fayetteville Departure Control.

FAYETTEVILLE
DEPARTURE CONTROL: TRAC zero one, copy climbing to eight thousand (8000), IDENT.

TRAC ZERO ONE: IDENTS.

FAYETTEVILLE
DEPARTURE CONTROL: TRAC zero one, radar contact, climb and maintain seven thousand (7000) expect eight thousand (8000) with Washington Center.

TRAC ZERO ONE: Acknowledges.

(halfway between Pope and Fayetteville)

FAYETTEVILLE
DEPARTURE CONTROL: TRAC zero one, Climb and maintain eight thousand (8000), contact Washington Center on one three five point two or three four eight point six five (135.2/348.65).

TRAC ZERO ONE: Acknowledges.

TRAC ZERO ONE: Contacts Washington Center.

WASHINGTON CENTER: TRAC zero one Radar Contact, I've got an amendment to your flight plan, advise when ready to copy.

TRAC ZERO ONE: Acknowledges and advises ready to copy.

WASHINGTON CENTER: TRAC zero one after Florence cleared Victor fifty-six (V56) Columbia, Victor thirty-seven (V37) Blots, Victor one fifty-five (V155) Chesterfield, direct the Pope two five zero radial at one two DME (250R/12), maintain eight thousand (8000), read back.

TRAC ZERO ONE: Reads back.

NOTE: At this point, have the crew engage the AFCS and update the flight plan.

(24 DME inbound to Florence)
WASHINGTON CENTER: TRAC zero one, contact Jacksonville Center on one three three point four five, or three three six point three (133.45/336.3).

TRAC ZERO ONE: Acknowledges.

TRAC ZERO ONE: Contacts Jacksonville Center

JACKSONVILLE CENTER: TRAC zero one, radar contact, maintain eight thousand (8000).

(Approximately 20 DME inbound to Columbia)
JACKSONVILLE CENTER: TRAC zero one, Jacksonville Center.

TRAC ZERO ONE: Acknowledges.

JACKSONVILLE CENTER: TRAC zero one, we'll need to change your altitude outbound from Columbia to match direction of flight. Would you like to climb or descend?

NOTE: If Trac zero one requests CLIMB, tell him to expect one one thousand (11,000); if trac zero one requests DESCENT, tell him to expect seven thousand (7,000).

JACKSONVILLE CENTER: TRAC zero one, Roger, expect (climb/descent) to (one one/seven) thousand (11,000/7000) crossing Columbia Vortac.

TRAC ZERO ONE: Acknowledges.

(At Columbia Vortac)
JACKSONVILLE CENTER: TRAC zero one, (climb/descent) and maintain (one one/seven) thousand (11,000/7000).

TRAC ZERO ONE: Acknowledges.

NOTE: At Chesterfield, use mission computer to fly direct to Pope two five zero radial at one two DME (250R/12).

(12 DME outbound from Chesterfield)

JACKSONVILLE

CENTER: TRAC zero one, Contact Washington Center on one three five point two or three four eight point six five (135.2/348.65).

TRAC ZERO ONE: Acknowledges.

TRAC ZERO ONE: Contacts Washington Center.

NOTE: This could be accomplished by switching UHF/VHF radios from 1 to 2 or visa versa since Washington Center was the station we were in contact with prior to Jacksonville.

(when TRAC zero one initiates contact)

WASHINGTON CENTER: TRAC zero one, radar contact, maintain (one one/seven) thousand (11,000/7000).

NOTE: Trac zero one should request descent for approach.

TRAC ZERO ONE: Request for descent.

WASHINGTON CENTER: TRAC zero one, descend pilot's discretion to three thousand (3000), contact Fayetteville approach on one one niner point five five or three niner three point zero (119.55/393.0).

TRAC ZERO ONE: Acknowledges. Contacts Fayetteville Approach.

(When TRAC zero one initiates contact)

FAYETTEVILLE

APPROACH CONTROL: TRAC zero one, maintain three thousand (3000), cleared ILS runway three six at Pope, winds calm, altimeter two niner niner two (29.92). Advise on course inbound.

TRAC ZERO ONE: Reads back.

TRAC ZERO ONE: Reports on course inbound.

(When TRAC zero one reports on course inbound)

FAYETTEVILLE

APPROACH CONTROL: TRAC zero one, contact Pope Tower on two niner one point one (291.1).

TRAC ZERO ONE: Acknowledges. (This frequency change and the rest throughout the scenario should be done using preset frequencies).

TRAC ZERO ONE: Contacts Pope Tower.

POPE TOWER: TRAC zero one, check wheels down (if not stated by TRAC zero one), wind calm, cleared to land. Contact Pope ground on rollout on two seven five point eight (275.8).

TRAC ZERO ONE: Acknowledges. (lands straight ahead stopping on runway)

MISSION #2

Mission start point will be overhead KPOB (Pope AFB) at 2000'. Crew has just completed touch and go land and is awaiting clearance from tower for round robin training.

TOWER CONTROLLER	TRAC zero one, Pope Tower.
TRAC ZERO ONE:	Responds.
TOWER CONTROLLER:	TRAC zero one, clearance available, advise when ready to copy.
TRAC ZERO ONE:	Acknowledges ready to copy.
TOWER CONTROLLER:	TRAC zero one is cleared to Pope, on climb-out turn left heading two two zero (220) intercept the Sandhills zero nine eight radial (098R) then as filed, climb and maintain eight thousand (8000 ft), contact departure control on one three three point zero or two niner five point zero (133.0/295.0) squawk three five zero one, advise when ready to depart.
TRAC ZERO ONE:	Reads back.
TRAC ZERO ONE:	Advises ready to depart
TOWER CONTROLLER:	TRAC zero one, contact departure control, Good Day.
TRAC ZERO ONE:	Acknowledges. (changes radio frequencies to depart)
TRAC ZERO ONE:	Contacts Fayetteville Departure Control.
FAYETTEVILLE DEPARTURE CONTROL:	TRAC zero one, copy climbing to eight thousand (8000), IDENT.
TRAC ZERO ONE:	IDENTS.
FAYETTEVILLE DEPARTURE CONTROL:	TRAC zero one, radar contact, climb and maintain six thousand (6000) expect eight thousand (8000) with Washington Center.
TRAC ZERO ONE:	Acknowledges.
(halfway between Pope and Sandhills)	
FAYETTEVILLE DEPARTURE CONTROL:	TRAC zero one, Climb and maintain eight thousand (8000), contact Washington Center on one three five point two or three four eight point six five (135.2/348.65).
TRAC ZERO ONE:	Acknowledges.
TRAC ZERO ONE:	Contacts Washington Center.
WASHINGTON CENTER:	TRAC zero one Radar Contact, I've got an amendment to your flight plan, advise when ready to copy.

TRAC ZERO ONE: Acknowledges and advises ready to copy.

WASHINGTON CENTER: TRAC zero one after Chesterfield cleared, Victor two fifty-nine (V259) Grand Strand, Victor one thirty-six (V136) Fayetteville, direct the Pope one eight zero radial at one two DME (180R/12), maintain eight thousand (8000), read back.

TRAC ZERO ONE: Reads back.

NOTE: At this point, have the crew engage the AFCS and update the flight plan.

(24 DME outbound from Sandhills)

WASHINGTON CENTER: TRAC zero one, contact Jacksonville Center on one three three point four five, or three three six point three (133.45/336.3).

TRAC ZERO ONE: Acknowledges.

TRAC ZERO ONE: Contacts Jacksonville Center

JACKSONVILLE CENTER: TRAC zero one, radar contact, maintain eight thousand (8000).

(Approximately 15 DME inbound to Chesterfield)

JACKSONVILLE CENTER: TRAC zero one, Jacksonville Center.

TRAC ZERO ONE: Acknowledges.

JACKSONVILLE CENTER: TRAC zero one, we'll need to change your altitude outbound from Chesterfield to match direction of flight. Would you like to climb or descend?

NOTE: If Trac zero one requests CLIMB, tell him to expect one one thousand (11,000); if trac zero one requests DESCENT, tell him to expect seven thousand (7,000).

JACKSONVILLE CENTER: TRAC zero one, Roger, expect (climb/descent) to (one one/seven) thousand (11,000/7000) crossing Chesterfield Vortac.

TRAC ZERO ONE: Acknowledges.

(At Chesterfield Vortac)

JACKSONVILLE CENTER: TRAC zero one, (climb/descent) and maintain (one one/seven) thousand (11,000/7000).

TRAC ZERO ONE: Acknowledges.

(33 DME outbound from Grand Strand)

JACKSONVILLE CENTER: TRAC zero one, Contact Washington Center on one three five point two or three four eight point six five (135.2/348.65).

TRAC ZERO ONE: Acknowledges.

TRAC ZERO ONE: Contacts Washington Center.

NOTE: This could be accomplished by switching UHF/VHF radios from 1 to 2 or visa versa since Washington Center was the station we were in contact with prior to Jacksonville.

(when TRAC zero one initiates contact)

WASHINGTON CENTER: TRAC zero one, radar contact, maintain (one one/seven) thousand (11,000/7000).

NOTE: At Fayetteville, use mission computer to fly direct to Pope two five zero radial at one two DME (250R/12).

NOTE: Trac zero one should request descent for approach.

TRAC ZERO ONE: Request for descent.

WASHINGTON CENTER: TRAC zero one, descend pilot's discretion to three thousand (3000), contact Fayetteville approach on one one niner point five five or three niner three point zero (119.55/393.0).

TRAC ZERO ONE: Acknowledges. Contacts Fayetteville Approach.

(When TRAC zero one initiates contact)

FAYETTEVILLE

APPROACH CONTROL: TRAC zero one, maintain three thousand (3000), cleared ILS runway three six at Pope, winds calm, altimeter two niner niner two (29.92). Advise on course inbound.

TRAC ZERO ONE: Reads back.

TRAC ZERO ONE: Reports on course inbound.

(When TRAC zero one reports on course inbound)

FAYETTEVILLE

APPROACH CONTROL: TRAC zero one, contact Pope Tower on two niner one point one (291.1).

TRAC ZERO ONE: Acknowledges. (This frequency change and the rest throughout the scenario should be done using preset frequencies).

TRAC ZERO ONE: Contacts Pope Tower.

POPE TOWER: TRAC zero one, check wheels down (if not stated by TRAC zero one), wind calm, cleared to land. Contact Pope ground on rollout on two seven five point eight (275.8).

TRAC ZERO ONE: Acknowledges. (lands straight ahead stopping on runway)

APPENDIX D
SWORD DATA COLLECTION FORM

PFF: EADI, EHSL, HUD

Mission Segment:

Crew # Pilot Co pilot

COMM/NAV: CNCP, CDU, HSF

Mission #

A/C SYSTEMS: ENGI, ENG2, CHIK

departure
cruise 1
reroute
cruise 2
descent
approach/land

Which control/display interface elicits more workload ?

	>>>>	>>>	>>	>	equal	<	<<	<<<	<<<<	
IRAC PFF	—	—	—	—	—	—	—	—	—	IRAC COMM/NAV
IRAC PTF	—	—	—	—	—	—	—	—	—	IRAC A/C SYSTEMS
IRAC PTF	—	—	—	—	—	—	—	—	—	REF PTF
IRAC PTF	—	—	—	—	—	—	—	—	—	REF COMM/NAV
IRAC PTF	—	—	—	—	—	—	—	—	—	REF A/C SYSTEMS
IRAC COMM/NAV	—	—	—	—	—	—	—	—	—	IRAC A/C SYSTEMS
IRAC COMM/NAV	—	—	—	—	—	—	—	—	—	REF PTF
IRAC COMM/NAV	—	—	—	—	—	—	—	—	—	REF COMM/NAV
IRAC COMM/NAV	—	—	—	—	—	—	—	—	—	REF A/C SYSTEMS
IRAC A/C SYSTEMS	—	—	—	—	—	—	—	—	—	REF PTF
IRAC A/C SYSTEMS	—	—	—	—	—	—	—	—	—	REF COMM/NAV
IRAC A/C SYSTEMS	—	—	—	—	—	—	—	—	—	REF A/C SYSTEMS
REF PTF	—	—	—	—	—	—	—	—	—	REF COMM/NAV
REF PTF	—	—	—	—	—	—	—	—	—	REF A/C SYSTEMS
REF COMM/NAV	—	—	—	—	—	—	—	—	—	REF A/C SYSTEMS

APPENDIX E
SWORD ANOVA TABLES

MISSION 1 DEPARTURE	MS	df	F	p
AIRCRAFT	0.05	1	4.78	0.048
SYSTEMS	0.03	2	1.14	0.334
AIRCRAFT BY SYSTEMS	0.06	2	5.88	0.008
AIRCRAFT BY SUBJECT	0.01	13		
SYSTEMS BY SUBJECT	0.02	26		
AIRCRAFT BY SYSTEMS BY SUBJECT	0.01	26		

MISSION 1 CRUISE 1	MS	df	F	p
AIRCRAFT	0.03	1	2.12	0.169
SYSTEMS	0	2	0.08	0.926
AIRCRAFT BY SYSTEMS	0.05	2	5.12	0.013
AIRCRAFT BY SUBJECT	0.01	13		
SYSTEMS BY SUBJECT	0.02	26		
AIRCRAFT BY SYSTEMS BY SUBJECT	0.01	26		

MISSION 1 REROUTE	MS	df	F	p
AIRCRAFT	0	1	0.22	0.644
SYSTEMS	0.16	2	8.57	0.001
AIRCRAFT BY SYSTEMS	0.03	2	3.1	0.062
AIRCRAFT BY SUBJECT	0.02	13		
SYSTEMS BY SUBJECT	0.02	26		
AIRCRAFT BY SYSTEMS BY SUBJECT	0.01	26		

MISSION 1 CRUISE 2	MS	df	F	p
AIRCRAFT	0.04	1	3.82	0.073
SYSTEMS	0.02	2	1.53	0.236
AIRCRAFT BY SYSTEMS	0.06	2	6.3	0.006
AIRCRAFT BY SUBJECT	0.01	13		
SYSTEMS BY SUBJECT	0.02	26		
AIRCRAFT BY SYSTEMS BY SUBJECT	0.01	26		

MISSION 1 DESCENT	MS	df	F	p
AIRCRAFT	0.1	1	14.01	0.002
SYSTEMS	0.02	2	0.9	0.417
AIRCRAFT BY SYSTEMS	0.04	2	3.91	0.033
AIRCRAFT BY SUBJECT	0.01	13		
SYSTEMS BY SUBJECT	0.02	26		
AIRCRAFT BY SYSTEMS BY SUBJECT	0.01	26		

MISSION 1 APPROACH/LANDING	MS	df	F	p
AIRCRAFT	0.07	1	8.46	0.012
SYSTEMS	0.09	2	3.36	0.05
AIRCRAFT BY SYSTEMS	0.06	2	6.96	0.004
AIRCRAFT BY SUBJECT	0.01	13		
SYSTEMS BY SUBJECT	0.03	26		
AIRCRAFT BY SYSTEMS BY SUBJECT	0.01	26		

MISSION 2 DEPARTURE	MS	df	F	p
AIRCRAFT	0	1	0.26	0.62
SYSTEMS	0.13	2	6.15	0.007
AIRCRAFT BY SYSTEMS	0	2	0.16	0.851
AIRCRAFT BY SUBJECT	0.01	13		
SYSTEMS BY SUBJECT	0.02	26		
AIRCRAFT BY SYSTEMS BY SUBJECT	0.01	26		

MISSION 2 CRUISE 1	MS	df	F	p
AIRCRAFT	0	1	0.01	0.912
SYSTEMS	0.12	2	6.91	0.004
AIRCRAFT BY SYSTEMS	0.01	2	1.47	0.249
AIRCRAFT BY SUBJECT	0.01	13		
SYSTEMS BY SUBJECT	0.02	26		
AIRCRAFT BY SYSTEMS BY SUBJECT	0.01	26		

MISSION 2 REROUTE	MS	df	F	p
AIRCRAFT	0.01	1	0.38	0.55
SYSTEMS	0.32	2	18.15	0
AIRCRAFT BY SYSTEMS	0.01	2	0.99	0.386
AIRCRAFT BY SUBJECT	0.02	13		
SYSTEMS BY SUBJECT	0.02	26		
AIRCRAFT BY SYSTEMS BY SUBJECT	0.01	26		

MISSION 2 CRUISE 2	MS	df	F	p
AIRCRAFT	0.01	1	0.35	0.565
SYSTEMS	0.18	2	10.06	0.001
AIRCRAFT BY SYSTEMS	0.01	2	0.89	0.424
AIRCRAFT BY SUBJECT	0.02	13		
SYSTEMS BY SUBJECT	0.02	26		
AIRCRAFT BY SYSTEMS BY SUBJECT	0.01	26		

MISSION 2 DESCENT	MS	df	F	p
AIRCRAFT	0	1	0.08	0.781
SYSTEMS	0.14	2	7.38	0.003
AIRCRAFT BY SYSTEMS	0	2	0.5	0.61
AIRCRAFT BY SUBJECT	0.02	13		
SYSTEMS BY SUBJECT	0.02	26		
AIRCRAFT BY SYSTEMS BY SUBJECT	0.01	26		

MISSION 2 APPROACH/LANDING	MS	df	F	p
AIRCRAFT	0	1	0.05	0.82
SYSTEMS	0.14	2	4.96	0.015
AIRCRAFT BY SYSTEMS	0	2	0.19	0.824
AIRCRAFT BY SUBJECT	0.02	13		
SYSTEMS BY SUBJECT	0.03	26		
AIRCRAFT BY SYSTEMS BY SUBJECT	0.01	26		

APPENDIX F
QUESTIONNAIRE DATA
ACCEPTABILITY RATINGS AND COMMENTS

SYSTEMS QUESTIONNAIRE

The following questions investigated the operability, intelligibility, effectiveness, and compatibility of TRAC's control/display units. The acceptability ratings listed below, (A through E), were used to quantify the acceptability of each control and display and its individual elements. Space was provided after each question for comments. For each question, the number of subjects giving a particular rating is provided. All subjects' comments follow each question, with the subject identified by subject number in parenthesis.

- A. Very acceptable:** a good design as is.
B. Moderately acceptable: minor issues having no impact on pilot performance.
C. Borderline: design flaws that could impact pilot performance; changes would be desirable.
D. Moderately unacceptable: design flaws impair pilot performance; corrections required.
E. Very unacceptable: Unsafe, impractical, and contributes greatly to mission failure; redesign required.

Electronic Attitude Direction Indicator--(EADI)

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
1. The size of the EADI unit is	9	4	1	0	0
S9. Not being an exact circle is somewhat distracting.					
S10. A little larger would be nice.					
S12. Don't close ADI up.					
S14. Could be larger.					
2. The contrast between the EADI's symbology and background is	11	3	0	0	0
S13. Color coded ADI is not useful.					
S14. But would not work with NVG's.					
3. The degree of clutter on the EADI is	4	8	1	1	0
S1. Move worm over to airspeed gauge.					
S8. The speed worm and acceleration cue seem unnecessary and contribute to the already cluttered EADI.					
S10. Up to the pilot.					
S12. It is easy to put too much on it. (A pilot controlled problem).					
S14. Some of the info available is unnecessary such as the waterline markings when flying in the flight path vector mode.					
4. The manner in which the information is presented on the EADI is	6	2	6	0	0
S2. Speed worm need to go by the airspeed, not on the attitude. The VVI tape needs to be bigger (wider).					
S10. The pitch steering bar should not be presented continuously. Only present it when applicable. like an ILS.					
S11. Space the 5 and 10 degree reference marks further apart. 11)					
5. The type of symbology used on the EADI is	6	6	2	0	0
S1. Speed worm is marginal.					
S10. I like the speed cues a lot.					
S14. Get rid of the 1 foot increments on the altimeter.					
6. The ease with which the EADI information can be interpreted is	6	6	2	0	0
S12. The speed worm can be tough to read.					

A B C D E

7. The color coding employed on the EADI is	9	5	0	0	0
8. The size of the altitude tape is	9	4	1	0	0
9. The position of the altitude tape is	11	3	0	0	0
10. The scaling of the altitude tape is	9	4	1	0	0
S2. You should go to 10' inc. instead of 1' inc.					
S3. Altitude numeric display would be better in 10' increments and not overlapping on the altitude scale, i.e. move numeric readout to right out of the way.					
11. The precision of the altitude tape is	6	3	3	2	0
S2. 10' increments.					
S2, S11. Too precise.					
S11. Delete the last digit to a zero. i.e. (2190, 2220).					
S12. Too precise. Scale it at 10 ft not one foot.					
S13. Make scale bolder in 1000' increments and have all #s same size.					
12. The presentation of the command altitude marker was	5	5	4	0	0
S2. The command markers should be centered.					
S10. Took some effort to incorporate into cross-check.					
S13. Make ALT bug a caret.					
S14. It is obscured when you are near or on altitude.					
13. The size of the vertical velocity indicator (VVI) is	2	2	1	3	6
S1. Must be larger.					
S2, S10, S14. Too small.					
S4. Give us a pointer instead of a tape which is the same color as the scale.					
S7. Tape too narrow and not contrasted enough with scale. Change color and make it wider. Green up, red down maybe?					
S8. The VVI display is unacceptable. The VVI indicator bar is much too small and lacks contrast. Recommend a colored, wider bar. VVI scale should be expanded.					
S9. Way too small (that is , the white sliding scale itself).					
14. The position of the VVI is	9	3	0	2	0
S10. Cluttered with altimeter.					
15. The scaling of the VVI is	6	2	0	4	2
S10. Larger block readout of actual VVI condition.					
Very shitty. Too small.					
S11. Make the tape more pronounced.					
S13. Take VVI scale off and make a solid bar and have VVI box indicate actual VVI all the time.					
S14. Don't have it stop at 1500.					
16. The precision of the VVI is	7	5	1	1	0
S10. Too small to discriminate precision.					
17. The ease with which the VVI information is interpreted is	0	3	3	2	6
S2. Due to the tape width being too small.					
S3. The narrow white tape on the white scale was very difficult to read. Better to					
	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>

have a pointer or a different color for indicator tape.					
S11. Make the tape more pronounced.					
S12. It can be hard to read the VVI tape. Use a pointer.					
18. The size of the bank angle indicator is		8	5	1	0 0
S10. A little small.					
19. The position of the bank pointer is		11	3	0	0 0
20. The symbology used for the bank pointer is		11	1	1	0 1
S9. I'm used to a thicker 30 degree marker, like you have on the HUD.					
21. The scale of the bank angle displayed is		10	3	1	0 0
S10. A little small. 30 and 60 degree marks should be much bolder.					
S11. Display turn degree marks with longer lines.					
22. The range of the bank angle scale is		13	1	0	0 0
23. The precision of the bank angle display is		11	3	0	0 0
S10. Larger scale would be more accurate.					
24. The fixed scale, moving pointer presentation of the bank angle display is		12	2	0	0 0
25. The general manner in which bank angle is displayed is		11	2	1	0 0
26. The size of the climb/dive indicator is		9	5	0	0 0
27. The scaling of the climb/dive indicator is		9	5	0	0 0
S7. Add 2 degree hash marks in the +10 to -10 degree range. At least 5 degree hash marks in this range would help climb/dive stabilization.					
28. The precision provided by the climb/dive indicator is		10	2	2	0 0
S1. Still prefer setting a pitch attitude.					
S8. The climb/dive marker is an excellent feature especially when combined with the water mark for judging aircraft performance at a glance.					
S10. Would like larger scale between 5 and 10 degree lines on ADI for greater precision. The HUD is better.					
29. The contrast of the climb/dive indicator against the "sky" is		10	2	1	0 0
S11. Could be more pronounced.					
30. The contrast of the climb/dive indicator against the "ground" is		11	1	1	0 0
31. The size of the airspeed tape is		12	2	0	0 0
32. The position of the airspeed tape is		12	2	0	0 0
S3. Airspeed pointer should be moved out of airspeed scale.					
S4. Move it over a bit (digital readout) away from the scale with a sharper point toward the scale.					
33. The scaling of the airspeed tape is		11	3	0	0 0
S3. Airspeed scale should be able to display MACH scale as well.					
		A	B	C	D E

S13. The airspeed tape should be bolder at 1000' increments and airspeed box

should not roll.

34. The precision of the airspeed tape is	11	3	0	0	0
S2. If you went to 5 KTS inc. would be better.					
35. The presentation of the commanded airspeed is	4	6	3	1	0
S1. Need to be able to mark other speeds, i.e. Rotate, Vmca, etc.					
S2. Needs to be moved to the center.					
S7. Extend the command line right and left some so it is more easily discernible that you are on commanded A/S or ALT.					
S9. How about a different color background.					
S10. Took some effort to incorporate into cross-check.					
S13. A/S bug should be a caret.					
S14. It is obscured when you are near or on airspeed.					
36. The symbology used for the horizon bar is	9	5	0	0	0
37. The size of the speed worm is	6	5	2	0	1
38. The position of the speed worm is	6	4	2	0	2
S1. Too much info on EADI, move over to airspeed tape.					
39. The scaling of the speed worm is	6	5	2	0	1
40. The precision of the speed worm is	7	5	1	0	1
41. The contrast of the speed worm against the "sky" is	8	3	1	1	1
S14. Hard to see at times.					
42. The contrast of the speed worm against the "ground" is	9	2	1	1	1
S11. Didn't really use it while flying. (Would have deselected it).					
S14. Easier than the sky, but still difficult at times.					
43. The symbology used for the speed worm is	5	5	1	2	1
S2. You really don't need the speed worm.					
S12. I don't like it. It gets in the way. (Is it necessary).					
44. The size of the acceleration cue is	7	3	3	0	0
S14. Too small.					
45. The position of the acceleration cue is	8	3	2	0	0
S8. Never noticed it. The ADI is too cluttered.					
S9. There was some accuracy problems with the acceleration cue.					
S12. Is the accel. cue necessary? I always turned it off.					
46. The contrast of the acceleration cue against the "sky" is	8	3	1	1	0
S14. Hard to see at times.					
47. The contrast of the acceleration cue against the "ground" is	8	3	1	1	0
S11. Deselected.					
S14. Easier than the sky, but still difficult at times.					
	A	B	C	D	E
48. The size of the climb/dive marker is	9	4	1	0	0
S9. Scale could be larger.					

49. The ease with which info is interpreted from the climb/dive marker is 8 4 2 0 0
S1. Just need experience with it.
S10. Great for the HUD, just good for the ADI. See question 28 above.
50. The compatibility of the climb/dive marker with the rest of the display is 9 3 2 0 0
51. The symbology used for the climb/dive marker is 10 3 1 0 0
52. The size of the flight path marker is 6 5 3 0 0
53. The ease with which information is interpreted from the flight path marker is 5 2 5 1 1
S1. Not used to it.
S10. Useless on the EADI.
S14. Hard to see with the other info over the top.
54. The compatibility of the flight path marker with the rest of the display is 6 4 2 1 1
S8. The flight path marker is really unnecessary when the climb/dive marker is available and contributes to EADI clutter.
55. The symbology used for the flight path marker is 6 5 3 0 0
S11. I could use more practice interpreting it.
56. The EADI display as a whole is 6 6 2 0 0
S4. MACH and GS numbers are positioned too close to, and same color as airspeed tape. They don't stand out.
S6. Super EADI. No comments.
S7. Bring a repeater of Flap and trim indicators into the EADI somewhere. Attitude mode very confusing. Climb/dive mode much easier to fly.
S11. Looks nice.
S12. A very good instrument, however, too much info can be presented. Pilot can deselect most of the clutter (an operator's problem). I do feel the acceleration cue and speed worm are unnecessary.
S13. Make ground speed indicator solid and more pointed. Too many choices for steering command. (ball, bar, etc.). Get new symbology that's more precise for a flight director cue.
S14. Overall , the basic design of the EADI is good. In some instances you have tried to provide too much information which tends to clutter the display. I don't feel the flight path marker is necessary. Just provide us with the actual drift readout somewhere. A speed cue is good, but don't think we need the speed worm (more clutter). Increase the size or readability of CMD airspeed and ALT. Definitely have the altimeter only increase by tens. The one foot increments drive me nuts. Have a VVI the goes all the way to zero.

Electronic Horizontal Situation Indicator--(EHSI)

- A. Very acceptable:** a good design as is.
B. Moderately acceptable: minor issues having no impact on pilot performance.
C. Borderline: design flaws that could impact pilot performance; changes would be desirable.
D. Moderately unacceptable: design flaws impair pilot performance; corrections required.
E. Very unacceptable: Unsafe, impractical, and contributes greatly to mission failure; redesign required.

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
1. The size of the EHSI unit is	11	2	1	0	0
S8. EHSI should be slightly larger (15%).					
S13. Too small.					
S14. Larger would be nicer.					
2. The contrast between the EHSI's symbology and background is	12	2	0	0	0
S1. The contrast V1, V2 station is confusing.					
S10. Selected Nav should appear in Magenta.					
3. The degree of clutter on the EHSI is	5	5	4	0	0
S6. Has possibly too many options for simultaneous display.					
S10. Get rid of the V1, V2 etc. frequencies.					
S12. It is easy to put too much info on the screen. Proper training and screen management should solve this.					
S13. Too much extraneous and similar symbology.					
4. The manner in which the information is presented on the EHSI is	6	5	2	1	0
S5. Would be nice if primary nav bearing pointer would come up automatically.					
S10. I like the course and DME on the top of the HSI, to the right & left respectively.					
5. The type of symbology used on the EHSI is	9	4	1	0	0
S13. Too similar.					
6. The ease with which the EHSI information can be interpreted is	7	4	2	1	0
S1. What I choose on the CNCP should be displayed on the HSI.					
S2. You need to raise and lower brightness.					
S10. Difficult to determine which bearing pointer is the primary nav pointer.					
7. The color coding employed on the EHSI is	9	4	1	0	0
S14. Could be more contrast in colors.					
8. The symbology used for the bearing pointer is	9	2	1	2	0
S10. Need Magenta for selected Nav.					
S13. Too similar, color and symbology.					
9. The contrast of the bearing pointer against the display background is	11	2	0	1	0
S10. Need Magenta for selected Nav.					
S6. EHSI big bearing pointer covers smaller bearing pointer.					
10. The symbology used for the course arrow is	12	2	0	0	0
11. The contrast of the course arrow is against the display background is	11	3	0	0	0

	A	B	C	D	E
12. The size of the course arrow (length and width) is	10	4	0	0	0
S13. Make bolder line.					
13. The symbology used for the course deviation indicator is	12	2	0	0	0
14. The contrast of the course deviation indicator against the background is	12	2	0	0	0
15. The size of the course deviation scale markers is	12	2	0	0	0
16. The symbology for the heading pointer is	11	0	2	1	0
S9. Look like a tail of a TAC, VOR etc. pointer.					
S10. Too easily confused with the tails of VOR2 and TAC2.					
S14. Needs to stand out more.					
17. The contrast of the heading pointer against the display background is	11	2	1	0	0
S14. Needs to stand out more.					
18. The size of the heading pointer is	11	2	1	0	0
S9. Look like a tail of a TAC, VOR etc. pointer.					
19. The EHSI display as a whole is	7	5	1	0	1
S1. Too many steps involved in selecting a nav aid. Unless I make the other pilot set up his HSI so I could cross check with another nav aid I would get disoriented. The added workload for him (CP) to help me plus do his normal duties are extremely high. Of course the pilot could tune in another nav aid if it was on autopilot.					
S7. Next to the distance segment in the lower left corner, enable another segment which will display what is selected on the EHSI Nav radio PDPs in addition to the primary radio info selected on the CNCP. Put a digital clock readout somewhere in the vicinity for approach and holding timing.					
S8. Distances from multiple TACANS and the mission computer should be available simultaneously.					
S11. Need a drift readout. I'm not satisfied with the way courses and heading set markers are placed on the screen. Is it possible to have a knob turn, and place course and set the marker, in front of each pilot to be used in addition to the current procedure?					
S13. Too cluttered.					
S14. For a Talon (MC-130H) type mission I would rather see the HSI and ADI separated, with a larger ADI by itself. HSI and ADI may be good together for strat, but the HSI is pretty useless for TAC. Have ADI be more like a Head Down HUD.					

Primary Flight Format PDPs

The EADI and EHSI are combined in the Primary Flight Format (PFF). Associated with the PFF are a set of Programmable Display Pushbuttons (PDPs). These are the touch sensitive boxes at the bottom of the display which allow the selection of a variety of format options. Please consider *only* the Primary Flight Format PDPs when responding to the following questions. Use the rating convention established for the previous questions.

- A. **Very acceptable:** a good design as is.
- B. **Moderately acceptable:** minor issues having no impact on pilot performance.
- C. **Borderline:** design flaws that could impact pilot performance; changes would be desirable.
- D. **Moderately unacceptable:** design flaws impair pilot performance; corrections required.
- E. **Very unacceptable:** Unsafe, impractical, and contributes greatly to mission failure; redesign required.

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
1. The sizes of the PDPs are	11	2	1	0	0
2. The number of PDPs available for the Primary Flight Format is	8	4	2	0	0
S2. Due to being too close together.					
S13. Too much extraneous choices.					
3. The clutter of the Primary Flight Format's PDPs is	8	3	1	0	1
S2. PDPs that aren't associated with that screen shouldn't be on the screen or move them to a different part of the screen.					
S8. The PDPs for selecting the EADI features are confusing. Too Many options.					
S9. What clutter?					
S13. Too close.					
4. The nomenclature/abbreviations used on the Primary Flight Format PDPs is	6	6	1	1	0
S5. A few of the buttons need a better description.					
S13. Use pilot lingo not English lingo.					
5. The organization of the Primary Flight Format PDPs is	6	5	1	1	1
S1. PDPs associated with other menu pages should be located on opposite side of panel from PDPs for selecting functions on the PFF display. I pulled up the HSF by mistake and didn't have an ADI to fly by momentarily, while I fumbled through the PDPs to bring the EADI back up.					
S6. Flight Director PDP should be moved closer to ATT/CLM DIV button.					
S7. Except for the center CRT, they worked fine and were very easy to learn and use.					
S8. The PDPs now allow you to deselect the primary flight format and get lost in other menu options. I'm not sure this screen should allow the other menu options, it should always display the PFF.					
S11. The touch screen kind of sucks. It doesn't take inputs from time to time. A push button format might be better.					
S12. Hard to find the spot to touch.					
S14. Need Real buttons, not touch screens.					

Head-Up Display--(HUD)

- A. **Very acceptable:** a good design as is.
 B. **Moderately acceptable:** minor issues having no impact on pilot performance.
 C. **Borderline:** design flaws that could impact pilot performance; changes would be desirable.
 D. **Moderately unacceptable:** design flaws impair pilot performance; corrections required.
 E. **Very unacceptable:** Unsafe, impractical, and contributes greatly to mission failure; redesign required.

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
1. The size of the Head-Up Display (HUD) is	10	2	1	0	1
S2. It is almost too small.					
2. The size of the HUD symbology is	2	2	3	3	4
S3. Too small for prolonged use.					
S4. Too small.					
S10. Kind of small.					
S11. Make it bigger.					
S13. Too small.					
S14. Way too small for read and interpret in a timely manner.					
3. The contrast between the HUD symbology and the background is	2	2	3	4	3
S2. Could be darker.					
S9. Tough to see in a quick glance.					
S10. Make it bolder to stand out more.					
S11. Make it sharper.					
S14. Can't see it without putting whole concentration on HUD rather than flying.					
4. The degree of clutter on the HUD is	3	8	1	1	1
S10. Let the pilot declutter what he/she wants to.					
S11. Too cluttered.					
5. The manner in which the information is presented is	4	9	0	0	1
6. The type of symbology used on the HUD is	7	5	1	0	1
7. The ease with which information from the HUD can be interpreted is	2	6	3	2	1
S2. Due to being too small.					
S9. Tough to see in a quick glance.					
S11. Might need some practice.					
8. The size of the heading indicator is	3	2	5	2	2
S3. Nice placement and scale.					
S4, S11. Too small.					
S14. Everything is too small.					
9. The position of the heading indicator is	8	5	0	0	1
S3. Nice placement and scale.					
10. The scaling of the heading tape is	7	3	2	1	1
S4. Too small.					
	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>

11. The precision of the heading tape is	8	5	0	0	1
12. The contrast of the heading indicator against the background is	3	1	7	2	1
S2. Too light with light backgrounds.					
S9. Tough to see in a quick glance.					
S10. Make it bolder to stand out more.					
S11. Make it sharper.					
S14. Needs to stand out more.					
13. The general manner in which the heading is displayed on the HUD is	5	5	3	0	1
S4. Size is too small					
S10. Small and blends in with background.					
14. The size of the calibrated airspeed (CAS) indicator is	0	3	4	5	2
S2. Way too small.					
S3. Size is too small.					
S4. Too small.					
S10. Small.					
S12. Too small.					
S13. Too small.					
S14. Everything is too small.					
15. The position of the CAS indicator is	7	6	0	0	1
16. The scaling of the CAS indicator is	4	4	3	2	1
S10. Too small.					
S11. Make it sharper and bigger.					
17. The precision of the CAS indicator is	7	5	1	0	1
18. The contrast of the CAS indicator against the background is	3	2	4	3	1
S2. Again too light against backgrounds.					
S9. Tough to see in a quick glance.					
S10. Make it bolder to stand out more.					
S14. Needs to stand out more.					
19. The symbology used to display CAS is	5	6	0	2	1
S10. Didn't use dots- had to squint to see them; small and blended in.					
S11. Use IAS.					
20. The size of the climb/dive indicator is	5	3	1	3	1
S3. Too small.					
S11. Make it sharper.					
S14. Everything is too small.					
21. The scaling of the climb/dive indicator is	8	4	0	0	1
22. The precision provided by the climb/dive indicator is	8	4	0	0	1
S10. Very good HUD.					
23. The contrast of the climb/dive indicator against the "sky" is	3	4	4	2	1
S9. Tough to see in a quick glance.					
	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>

S10. Make it bolder to stand out more					
S14. Needs to standout more.					
24. The contrast of the climb/dive indicator against the "ground" is	4	5	3	1	1
S9. Tough to see in a quick glance.					
S10. Make it bolder to stand out more.					
S14. Needs to standout more.					
25. The position of the altimeter is	8	5	0	0	1
26. The scaling of the altimeter is	5	4	3	1	1
S10. Small.					
S12. Numbers are too small.					
27. The precision of the altimeter is	8	5	0	0	1
28. The contrast of the altimeter against the background is	3	2	4	4	1
S9. Tough to see in a quick glance.					
S10. Make it bolder to stand out more.					
S14. Needs to standout more.					
29. The symbology used to display altitude on the HUD is	4	5	3	1	1
S12. Numbers are too small.					
30. The position of the navigation box is	5	6	2	0	1
S13. Move to right side.					
31. The size of the navigation box is	1	4	3	4	2
S4. Small.					
S10. Way too small.					
S14. Too small.					
32. The contrast of the navigation box is	3	3	5	2	1
S9. Tough to see in a quick glance.					
S10. Make it bolder to stand out more.					
S14. Needs to standout more.					
33. The ease with which information can be obtained from the navigation box is	1	3	3	4	2
S9. O.K. I guess, I never really used it.					
S10. How's your vision?					
S12. Too small.					
34. The symbology used for the climb/dive marker is	9	4	0	0	1
35. The size of the climb/dive marker is	5	3	3	1	2
S14. Too small.					
36. The contrast of the climb/dive marker against the background is	5	2	3	3	1
S2. Contrast.					
S9. Tough to see in a quick glance.					
S14. Needs to standout more.					
	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
37. The symbology used for the flight path marker is	8	4	1	0	1

38. The size of the flight path marker is 5 2 1 3 3
S2. Too Small.
S14. Too small.
39. The contrast of the flight path marker against the background is 3 2 3 4 2
S2. Too light
S9. Tough to see in a quick glance.
S10. Make it bolder to stand out more
S14. Needs to standout more.
40. The symbology used for the bank indicator is 9 2 1 0 1
41. The size of the bank indicator is 1 4 1 4 4
S3. Small.
S4. Too small.
S10, S12, S14. Too small.
42. The contrast of the bank indicator against the background is 3 2 3 4 2
S9. Tough to see in a quick glance.
S10. Make it bolder to stand out more.
S14. Needs to standout more.
43. The HUD display as a whole is 2 5 3 3 1
S1. Didn't use HUD at all because of: contrast poor, size of air speed too small, climb dive marker too cluttered. Would need more time with HUD to be able to fairly rate its usefulness.
S2. It needs work to increase size and contrast.
S5. All markings need to be larger and have more contrast.
S6. Airspeed, Altitude, and Bank Indicator need to be bigger.
S7. Need to increase size of all characters. Need to contrast all characters much more with ground and sky backgrounds.
S8. All symbology is too small. If it were expanded and the contrast improved it would be pretty good.
S9. I like it a lot. Heavies should have gotten HUD's a long time ago.
S11. The HUD is useful but, it needs larger symbols and sharper displays. I do not care for the airspeed and altimeter gages on the HUD. I thought the navigation box was almost useless. I really did like the precision of the altitude scale.
S12. Some items are hard to read because they are too small. a variable brightness control should help contrast against a fog/cloudy background.
S14. For the Talon mission, we don't necessarily need a HUD because our mission is based on flying in the WX where a HUD is useless. I would like to have one for VIS flying.

Communication/Navigation Control Panel--(CNCP)

- A. **Very acceptable:** a good design as is.
- B. **Moderately acceptable:** minor issues having no impact on pilot performance.
- C. **Borderline:** design flaws that could impact pilot performance; changes would be desirable.
- D. **Moderately unacceptable:** design flaws impair pilot performance; corrections required.
- E. **Very unacceptable:** Unsafe, impractical, and contributes greatly to mission failure; redesign required.

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
1. The position of the Communication/Navigation Control Panel (CNCP) is	9	3	1	1	0
S3. Perfect.					
S9. Super positioning.					
S11. Too high and in field of view.					
S12. Blocks too much outside visibility.					
S14. Should not be on the wind screen because it obscures too much vision.					
2. The size of the CNCP unit is	9	4	1	0	0
S3. Smaller would be better.					
S9. Somewhat big.					
3. The ease of operating the CNCP is	8	5	0	1	0
4. Switching menus on the CNCP is	10	4	0	0	0
5. The number of keystrokes needed to accomplish an entry (or deletion) is	7	4	2	0	1
S2. Due to the fact that you should be able to bring up the primary bearing pointer when you select primary nav radios.					
S13. Need letter pad input cap.					
6. Executing key punches on the CNCP is	9	4	1	0	0
7. The size of the CNCP's LCD display is	10	3	1	0	0
S3. Smaller would be better.					
8. The readability of the CNCP's LCD display is	10	2	1	1	0
S10. Parallax distorts color and readability.					
9. The degree of clutter on the CNCP is	10	2	1	1	0
10. The ability to monitor the other pilot's CNCP activity is	1	3	7	2	1
S2. Due to backgrounds.					
S9. As a pilot the co-pilots get washed out.					
S10. Can't see Pilot's scratchpad from right seat					
S12. Too far away/bad angle.					
S14. Difficult to see his screen from the angle we sit at.					
11. The manner in which information was presented on the CNCP is	7	5	1	1	0
S11. A good idea if you can deselect that mode.					
12. Having the pilot's and co-pilot's CNCP "slaved" to one another is	4	7	2	0	1
S1. Plus another way the pilots can send A/S headings to each instead of the					
	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>

"Big Reach" to set the other's markers.

S9. A good idea. Lets do it.

S10. Confusing at first.

S14. Good sometimes and bad at others. Make it selectable.

13. The CNCP control/display unit as a whole is

7 4 3 0 0

- S1. In a high density traffic area we could be violated because it takes both pilots punching buttons, and switching nav aids, altitudes, etc., and it is impossible to be putting in input and trying to insert different things and we keep canceling each other out. Try: Splitting the screen, half Nav Comm with additional pages, much better workload arrangement.
- S2. You need to be able to set up other pilots information sometimes due to work loads. Why not make the page one before all of comm1/nav1 and page 2 for all of comm/nav2. Also there needs to be a way to send heading altitude airspeed, commands to the other pilot.
- S5. Don't like putting in the course on the CNCP and then input to the HSI.
- S6. Very nice unit.
- S7. This panel is probably too high on the glare screen for normal outside viewing. (will block view) Enable a calculate function on these boxes.
- S8. Very good system.
- S11. The unit is mounted too high. A helpful addition could be to be able to type the 3 letter identifiers of the nav aid as well as the number of the station.
- S13. Very helpful, but too cluttered with information not required.
- S14. Overall concept is good. You need to find a place where both pilots can see both screens.

Control Display Unit--(CDU)

- A. **Very acceptable:** a good design as is.
- B. **Moderately acceptable:** minor issues having no impact on pilot performance.
- C. **Borderline:** design flaws that could impact pilot performance; changes would be desirable.
- D. **Moderately unacceptable:** design flaws impair pilot performance; corrections required.
- E. **Very unacceptable:** Unsafe, impractical, and contributes greatly to mission failure; redesign required.

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
1. The position of the Control Display Unit (CDU) is	12	1	1	0	0
S1. 'Direct-to' switch should not change the menu. Should just enable the function to be able to go 'Direct-to' that point on the flight plan page.					
S9. Tough to read inside edge of cross cockpit CDU.					
2. The size of the CDU unit is	13	1	0	0	0
S1. Center display hard to read i.e. TRK bit.					
S3. Position is excellent.					
3. The ease of operating the CDU is	5	6	3	0	0
4. Switching menus on the CDU is	7	5	2	0	0
5. The number of keystrokes needed to accomplish an entry (or deletion) is	5	6	2	1	0
6. Executing key punches on the CDU is	7	5	2	0	0
S2. The key pad should be tilted for ease of entering data.					
7. The size of the CDU's LCD display is	9	4	1	0	0
8. The readability of the CDU's LCD display is	7	5	2	0	0
S10. Parallax distorts readability.					
S13. Too cluttered.					
9. The degree of clutter on the CDU is	6	6	1	1	0
10. The ability to monitor the other pilot's CDU activity is	4	4	4	2	0
S9. Tough to read inside edge of cross cockpit CDU.					
S10. Parallax distorts readability.					
S13. Too cluttered.					
11. The manner in which information was presented on the CDU is	5	8	0	1	0
S10. Need to display radial/DME. Need to be able to enter coordinates.					
12. The CDU control/display unit as a whole is	4	8	2	0	0
S2. 'Direct-to' should not give you a new page but it should give us the option to go 'Direct-to' the point from the flight plan page.					
S5. Could not see the co-pilots first letter of identifier. When inputting info. the scratch pad letters were too small to read.					
S6. Needs to accept Lat./Long. Needs to accept an identifier with a radial/DME at the same time.					
S7. There needs to be a switch that allows you to select which CDU is the active or primary controlling unit					
	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>

so the other CDU can be used for off-line flight plan changes or off line direct to "what ifs". Put calculator function on it. Allow for preselected flight plan entry (one button entry).

- S8. Pretty good set up. The angle of the screen and the position of the right side switches partially blocks the right most part of the screen (for co-pilot). The waypoint numbers should be to the left of the waypoint identifiers, i.e. on the same line.
- S11. The CDU was inoperable about 5 times during our training. Greater reliability is need in this piece of equipment.
- S12. The CDU's locked-up several times during our missions.
- S13. Screen was too bright and too much extra info cluttered up mission essential info.
- S14. I like the CDU as a whole. It's nice to be able to program fit plans and points.

Horizontal Situation Format--(HSF)

- A. **Very acceptable:** a good design as is.
- B. **Moderately acceptable:** minor issues having no impact on pilot performance.
- C. **Borderline:** design flaws that could impact pilot performance; changes would be desirable.
- D. **Moderately unacceptable:** design flaws impair pilot performance; corrections required.
- E. **Very unacceptable:** Unsafe, impractical, and contributes greatly to mission failure; redesign required.

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
1. The size of the Horizontal Situation Format (HSF) is	14	0	0	0	0
2. The contrast between the HSF symbology and the background is	14	0	0	0	0
3. The degree of clutter on the HSF is	9	4	1	0	0
S1. When re-routed, need to drop old route.					
S14. Depends on how much info you have called up (some of which may be unnecessary).					
4. The manner in which the information is (or can be) presented on the HSF is	11	3	0	0	0
S14. The CRS/HDG/ETE/DKT need to be larger and more prominently displayed.					
5. The type of symbology used on the HSF is	11	2	1	0	0
6. The ease with which the HSF information can be interpreted is	11	3	0	0	0
S9. Super.					
7. The way point symbology is	11	2	1	0	0
S2. Way points should be dropped after passage.					
8. The aircraft symbology is	12	2	0	0	0
9. The available ranges of the HSF are	8	2	1	1	2
S2. You need to have the cap to go to a min. of 300 NM.					
S3. More ranges to greater distances would be nice.					
S11. Another range to plot out the entire flight plan, regardless of distance would be necessary.					
10. The HSF display as a whole is	9	4	0	0	1
S1. Need up to 300 NM ranges.					
S5. Would be nice when inside 30 mile range there would be rings for every mile, in another color- different from the 10, 20, 30 mile rings.					
S7. Increase top scale to 240 NM or something higher than 120 NM.					
S8. The airfield depiction should show the actual runway headings, Tacans, VOR's, NDB, and geographic way points should all have different symbols corresponding to standard chart symbols.					
S9. Really like this system. Don't like the large red display when you go below 1000'. How about letting the pilot set it and all #'s below his setting will show up red on the altitude indications on the PFF.					
S10. Have option to orient with 360 degrees at top so one can cross-reference with the map in the lap. Get rid of that damned too-low red X.					
S11. HSF is a great addition.					
S12. The "too low" warning is very distracting. Maybe a small flashing "too low" light in the corner by your altimeter would be better.					

A B C D E

- S13.** Need trend dots and lose the radar path. Add time status, Delta time and increase size.
- S14.** Trend Dots! Get rid of the radar sweep representation.

Horizontal Situation Format PDPs

Associated with the HSF are a set of Programmable Display Pushbuttons (PDPs). These are the touch sensitive boxes at the bottom of the display which allow the selection of a variety of format options. Please consider *only* the Horizontal Situation Format PDPs when responding to the following questions. Use the rating convention established for the previous questions.

- A. **Very acceptable:** a good design as is.
- B. **Moderately acceptable:** minor issues having no impact on pilot performance.
- C. **Borderline:** design flaws that could impact pilot performance; changes would be desirable.
- D. **Moderately unacceptable:** design flaws impair pilot performance; corrections required.
- E. **Very unacceptable:** Unsafe, impractical, and contributes greatly to mission failure; redesign required.

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
1. The sizes of the PDPs are	11	3	0	0	0
2. The number of PDPs available for the Horizontal Situation Format is	10	3	1	0	0
S13. Too many choices that are not necessary. Use software for better programs.					
3. The clutter of the Horizontal Situation Format's PDPs is	9	3	1	1	0
4. The nomenclature/abbreviations used on the HSF PDPs is	6	5	2	1	0
S5. Buttons are large enough to put the entire name in small letters on some of them.					
S13. Use pilot lingo.					
5. The organization of the Horizontal Situation Format PDPs is	6	7	1	0	0
S7. Again, except for center CRT, PDPs are fine the way they are.					
S8. It is very easy to get lost in some of the options. Recommend a "menu" key that remains constant in position and function throughout all pages. This key should return you to a primary main menu.					
S14. No touch screens. Get real buttons.					

Engine Status Format--(ENG1)

- A. Very acceptable:** a good design as is.
B. Moderately acceptable: minor issues having no impact on pilot performance.
C. Borderline: design flaws that could impact pilot performance; changes would be desirable.
D. Moderately unacceptable: design flaws impair pilot performance; corrections required.
E. Very unacceptable: Unsafe, impractical, and contributes greatly to mission failure; redesign required.

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
1. The size of the Engine Status Format (ENG1) is S13. Too small.	10	2	1	1	0
2. The contrast between the ENG1's symbology and the background is	12	2	0	0	0
3. The degree of clutter on the ENG1 is S3. Reduce the excess scale above red-line values and expand the scale in the operating range. S10. Fuel flow too much. Moves too much. S11. Very cluttered.	6	5	3	0	0
4. The manner in which the information is presented on the ENG1 is	8	4	2	0	0
5. The grouping of performance parameters as they are on the ENG1 is S4. I want a fuel flow tape.	9	3	2	0	0
6. The ease with which the ENG1 information can be interpreted is S4. Fuel flow is difficult.	8	4	2	0	0
7. The color coding employed on the ENG1 is	11	2	1	0	0
8. The size of the EPR portion of the display is S4. Do not need the numerical values of the 4 EPR readings at the top. Clutter. Make each gauge 1/2 inch thinner and put a FF gauge at far right.	9	3	2	0	0
9. The position of the EPR portion of the display is	11	1	2	0	0
10. The scaling of the EPR tapes is S3. Reduce the excess scale above red-line values and expand the scale in the operating range. S6. Scaling on the gauges is unacceptable for several phases of operation. S8. The scale needs to be expanded. It is very difficult to operate in the narrow "normal" range as it now stands. S13. Too much.	5	2	5	1	1
11. The range of the EPR tapes is S3. Reduce the excess scale above red-line values and expand the scale in the operating range. S6. Range on the gauges is unacceptable for several phases of operation. S9. Wasted room at top.	6	2	4	1	1
12. The precision of the EPR tapes is	8	4	2	0	0
	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>

13. The size of the N1 and N2 portions of the display is	9	3	1	1	0
S4. Make each gauge 1/2 inch thinner and put a FF gauge at far right.					
S9. Wasted room at top.					
S11. If we fly N2 primarily, then N2 should be large.					
14. The position of the N1 and N2 portions of the display is	10	2	1	1	0
15. The scaling of the N1 and N2 tapes is	4	2	4	2	2
S3. Reduce the excess scale above red-line values and expand the scale in the operating range.					
S5. Scale on the N1 and N2 is too small between 0% and 80%. Needs to be more precise to allow Eng start.					
S6. Scaling on the gauges is unacceptable for several phases of operation.					
S8. The scale needs to be expanded. It is very difficult to operate in the narrow "normal" range as it now stands.					
S10. Wasted room at the top.					
S11. The tapes should be scaled in a way to make the usable range much larger.					
S13. Too much.					
16. The range of the N1 and N2 tapes is	5	2	5	1	1
S3. Reduce the excess scale above red-line values and expand the scale in the operating range.					
S6. Range on the gauges is unacceptable for several phases of operation.					
S9. Wasted room at top.					
S13. Too high.					
17. The precision of the N1 and N2 tapes is	9	3	1	1	0
S10. I don't need tenths displayed. It merely distracts me by moving around so much.					
18. The size of the EGT portion of the display is	10	2	2	0	0
S4. Make each gauge 1/2 inch thinner and put a FF gauge at far right.					
19. The position of the EGT portion of the display is	11	2	1	0	0
20. The scaling of the EGT tapes is	5	3	4	1	1
S3. Reduce the excess scale above red-line values and expand the scale in the operating range.					
S8. The scale needs to be expanded. It is very difficult to operate in the narrow "normal" range as it now stands.					
21. The range of the EGT tapes is	7	1	5	1	0
S3. Reduce the excess scale above red-line values and expand the scale in the operating range.					
S6. Range on the gauges is unacceptable for several phases of operation.					
S9. Large range.					
22. The precision of the EGT tapes is	10	2	2	0	0
23. The digitally supplied oil PSID is	9	2	3	0	0
24. The digitally supplied oil temperature is	10	2	2	0	0
	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>

25. The digitally supplied oil quantity is 10 1 1 0 1
 S3. Don't want it, or need it. Hook it to an idiot light.
26. The digitally supplied fuel quantity is 10 2 2 0 0
27. The ENG1 display as a whole is 3 7 4 0 0
- S1. On my engine failure, after handling the problem I noticed the failure caution, and I thought I lost the #2 Engine because of it's location.
- S2. The only change would be in the information area. For example, "Engine Failure" move them (the text) closer together.
- S4. All numerical values in green at top are useless to me.
- S8. Digital displays of Temps, pressures, quantities, etc. without a corresponding analog display is much less effective. I would like to see both digital and analog for all engine functions.
- S10. A lot of movement distracts me when the throttles are still.
- S11. The caution area should be more dynamic in the way it alerts pilots as to the condition of their aircraft. (i.e. flashing display, etc.).
- S12. Rearrange format to put most important engine parameter to the left. Change the scaling to enlarge the normal operating range. We need a better warning system telling about system failures, i.e. a master caution light that would be real obvious to see.
- S13. Scale too big and too cluttered.
- S14. Another possible format would be where you can choose the most important parameter in a larger and more precise presentation with the other systems being monitored by a computer which will provide warnings if any of the other systems goes out of limits.

Engine 1 Format PDPs

Associated with the ENG1 format are a set of Programmable Display Pushbuttons (PDPs). These are the touch sensitive boxes at the bottom of the display which allow the selection of a variety of format options. Please consider *only* the Engine 1 Format PDPs when responding to the following questions. Use the rating convention established for the previous questions.

- A. **Very acceptable:** a good design as is.
- B. **Moderately acceptable:** minor issues having no impact on pilot performance.
- C. **Borderline:** design flaws that could impact pilot performance; changes would be desirable.
- D. **Moderately unacceptable:** design flaws impair pilot performance; corrections required.
- E. **Very unacceptable:** Unsafe, impractical, and contributes greatly to mission failure; redesign required.

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
1. The sizes of the PDPs are	11	3	0	0	0
2. The number of PDPs available for the Engine 1 Format is	10	3	1	0	0
3. The clutter of the Engine 1 Format's PDPs is	9	4	0	0	0
4. The nomenclature (or abbreviations) used on the Engine 1 Format PDPs is	7	6	1	0	0
S7. Once abbreviations are learned, they are easy to read and use.					
5. The organization of the Engine 1 Format PDPs is	9	3	1	0	0
S8. This screen needs a main menu button that remains constant in function and position on all pages. This will allow you to get out of any function and back to a logical starting point.					

Alternative Engine Display--(ENG2)

- A. **Very acceptable:** a good design as is.
- B. **Moderately acceptable:** minor issues having no impact on pilot performance.
- C. **Borderline:** design flaws that could impact pilot performance; changes would be desirable.
- D. **Moderately unacceptable:** design flaws impair pilot performance; corrections required.
- E. **Very unacceptable:** Unsafe, impractical, and contributes greatly to mission failure; redesign required.

	A	B	C	D	E
1. The size of the Engine Status Format (ENG2) is	7	6	0	0	1
2. The contrast between the ENG2's symbology and the background is	7	4	2	0	1
S3. Difficult to read because 6 tapes of non-aligned information are too close.					
3. The degree of clutter on the ENG2 is	4	5	2	1	2
4. The manner in which the information is presented on the ENG2 is	2	0	1	2	9
S1. It sucked. Hard to cross-check!.					
S3. Difficult to know what limits are for red line or markers.					
S4. OP and OT need not be on a tape; FF does.					
Double layer tapes add to confusion.					
S8. Too many parameters displayed together in each engine grouping. OT & OP not necessary in this grouping.					
S9. Hate it. Confusing, disorienting.					
S12. Info is not presented in a logical manner.					
S14. I have a lot of trouble interpreting this format.					
5. The grouping of performance parameters as they are on the ENG2 is	2	0	2	3	7
S3. Put performance and engine groups together (i.e. EPR, N1, & N2; and EGT, OP, & OT).					
S5. The tapes allow a quicker glance that all 4 engs are about the same.					
This display would be fine for an engineer that had the time to read all the info.					
S7. Put oil parameters on the bottom and N1, N2, and EPR on top.					
S9. Tough to read.					
S10. I like parameters grouped together, not engines.					
S14. It may be because I'm not used to it, but, this format is hare to read.					
6. The ease with which the ENG2 information can be interpreted is	0	0	2	4	8
S4. How do you get to a preset power setting-numerical values are to difficult to set.					
You are too busy when your taking-off and landing.					
S5. The info is too spread out and hard to pick out. Takes too much attention to get the power set.					
S8. This method of presenting information is very difficult to interpret.					
S9. Tough to read.					
S11. Very hard to determine what the aircraft was actually doing.					
S12. This display is very confusing.					
Power settings are very hard to set.					
S13. Hard to monitor specific engine parameters.					
7. The color coding employed on the ENG2 is	7	3	1	1	2
S7. White background is terrible. Make numerals white, leave green tape, delete					
	A	B	C	D	E

white background.

S9. Very much like the red coloring of an engine with a malfunction.

S10. I like the green boxes around the engine.

S11. I did like the color coding of each engine.

8. The ENG2 display as a whole is

0 0 3 5 6

S6. We have no use for this design. It would work fine if we only monitored them, but for manipulation, they are almost, but not quite, useless. We don't use baseline values.

S7. Unless you have nothing else to do, setting power on this display is difficult at best.

S11. Didn't like it.

S12. Get rid of this!

Engine 2 Format PDPs

Associated with the ENG2 format are a set of Programmable Display Pushbuttons (PDPs). These are the touch sensitive boxes at the bottom of the display which allow the selection of a variety of format options. Please consider *only* the Engine 2 Format PDPs when responding to the following questions. Use the rating convention established for the previous questions.

- A. **Very acceptable:** a good design as is.
- B. **Moderately acceptable:** minor issues having no impact on pilot performance.
- C. **Borderline:** design flaws that could impact pilot performance; changes would be desirable.
- D. **Moderately unacceptable:** design flaws impair pilot performance; corrections required.
- E. **Very unacceptable:** Unsafe, impractical, and contributes greatly to mission failure; redesign required.

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
1. The sizes of the PDPs are	10	3	0	0	1
2. The number of PDPs available for the Engine 2 Format is	8	3	1	0	2
S1. Too many					
3. The clutter of the Engine 2 Format's PDPs is	7	4	1	0	2
4. The nomenclature (or abbreviations) used on the Engine 2 Format PDPs is	8	4	1	0	1
5. The organization of the Engine 2 Format PDPs is	7	4	1	0	2
S1. Too scattered out. Need to group.					
S8. This screen needs a main menu button that remains constant in function and position on all pages. This will allow you to get out of any function and back to a logical starting point. (8)					
S9. I like #1's format better; All in a one row.					
S13. Put engine stuff on top, everything else on bottom.					

Automatic Flight Control System--(AFCS)

- A. Very acceptable:** a good design as is.
B. Moderately acceptable: minor issues having no impact on pilot performance.
C. Borderline: design flaws that could impact pilot performance; changes would be desirable.
D. Moderately unacceptable: design flaws impair pilot performance; corrections required.
E. Very unacceptable: Unsafe, impractical, and contributes greatly to mission failure; redesign required.

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
1. The position of the AFCS is	7	3	3	1	0
S11. Too high on the control panel.					
S12. Blocks too much outside visibility.					
S14. Move it off the wind screen.					
2. The size of the AFCS is	5	5	3	1	0
S3. Smaller would be nice.					
S9. Rather larger.					
S12. Too large.					
S13. Too big.					
S14. It would be nice if the size could be reduced.					
3. The ease of operating the AFCS is	4	4	4	2	0
S1. Get rid of toggles.					
S3. Difficult to see controls, and knobs on autopilot are hard to set.					
S4. The APP PATH, MACH/IAS, HDG, ALT, and VERT SPD buttons should be part of each pilots numeric keypad so you don't have to reach so far.					
S5. Don't like updating and only one set of instruments updates. Both pilot's and copilot's side should update. (When one pilot has numbers in the scratchpad and the other pilot tries to update, the autopilot doesn't).					
S6. Rotary switches need two levels of change: Fast and Slow.					
S10. The AP should not have to be reset each time a new function is activated.					
S11. Too many buttons to push.					
4. Making selections using the rotary selector switches on the AFCS is	3	4	4	2	0
S1. Change bank angle knob. Get rid of and incorporate in with the heading.					
S9. Didn't use it much.					
S14. Didn't really use them.					
5. The size of the AFCS' LED display is	8	5	1	0	0
S14. Could be smaller.					
6. The readability of the AFCS' LED display is	10	4	0	0	0
7. The degree of clutter on the AFCS is	4	6	3	1	0
S2. Replace toggle switch with rotary.					
S11. Too cluttered.					
8. The ability to monitor the other pilot's AFCS activity is	5	3	2	4	0
S13. Unable to monitor inputs.					
9. The manner in which information is presented on the AFCS is	4	6	4	0	0
S1. VVI rate 10' increment not 1'.					
	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>

S10. VVI shouldn't be in units of 1'. Moves around too much. Use larger units.

10. The AFCS unit as a whole is

4 5 4 1 0

- S1. Easier way to pass information to both crew positions.
- S2. Need to light the face plate for night ops.
- S4. The autopilot switch should be bigger-more obvious as the key switch.
- S5. Hard to see the set buttons when dark.
- S6. Reaching across is cumbersome.
- S7. The control unit is too high. It looks like it will block both pilots' views if they look outside across cockpit.
- S8. The location of the ATS and AP switches next to each other is confusing. Should be separated on the panel. AP engage switch should be larger.
- S11. I really think you should be able to unclutter the AFCS. There seems to be too many buttons and functions. Simplify it.
- S12. It is too large, too many buttons. We need manual controls for steering.
- S14. I like the autopilot and what it displays on it's LEDs.

GENERAL TRAC SYSTEMS

- A. **Very acceptable:** a good design as is.
- B. **Moderately acceptable:** minor issues having no impact on pilot performance.
- C. **Borderline:** design flaws that could impact pilot performance; changes would be desirable.
- D. **Moderately unacceptable:** design flaws impair pilot performance; corrections required.
- E. **Very unacceptable:** Unsafe, impractical, and contributes greatly to mission failure; redesign required.

	A	B	C	D	E
1. The position of the side mounted force stick is	8	3	3	0	0
S1. Must incorporate an adjustable arm rest like AIRBUS uses, i.e. electric pitch, bank, position fwd aft.					
S2. Back too far.					
S3. Stick on copilot's side is more comfortable to use.					
S6. Stick is in a great position.					
S9. Love having all this room with nothing blocking my screens.					
2. The operability of the side mounted force stick is	1	4	3	2	4
S1. Sim needs to be more responsive. Could not have flown as well as I did without all the flying we did previous to the eval.					
S3. Requires a lot of force at times.					
S6. Stick is too sensitive, trim is too slow.					
S9. Tough to get used to.					
S10. Stick should actually move.					
S11. It sucked.					
3. Compared to what you're accustomed to, TRAC with the side mounted force stick is	2	3	3	2	4
S2. I really like the side mounted stick. The stick needs to be more responsive.					
S3. I like the side stick immensely. The view of the instruments and ease of stick on hand and arm is excellent.					
S4. Excellent-out of the visual way of instruments. Comfortable.					
S5. Don't like the button on the thumb rest.					
S7. Once used to it, it was fairly easy to use. You must get away from trying to actually move stick.					
S8. The non-movable stick is very difficult to use because of the limited tactile feedback. A movable side stick would be great.					
S9. Love having all this room with nothing blocking my screens. Let's do it.					
S11. It really sucked. The stick needs some displacement. I do not like the force stick.					
S12. The shape of the copilot's stick is better. A displacement stick would be much better. I think with these improvements the side mounted stick is the way to go.					
S14. Give me my big ol' yoke back. The side mounting idea is good giving you better visibility of the screens and more work area. I think a side mounted normal stick would be good once I learned to use it.					
4. The usability of the touch sensitive panels is	3	4	1	1	5
S3. Sometimes out of line.					
S10. Center touch boxes not aligned properly.					
S11. It didn't take our inputs in a timely manner.					
5. The ease with which the touch sensitive panel is operated is	5	2	1	0	6
S1. Had to constantly hunt for the right position.					
	A	B	C	D	E

S6. The touch panels were difficult due to imprecise placement.

S10. Pilot's and copilot's were fine , center panel was difficult.

6. In your opinion, touch sensitive panels would be _____ in future cockpits is 5 1 4 1 2

S2. The touch panels require a high degree of centering for the buttons to be effective.

S3. Beats the hell out of toggle switches. Very convenient and uses less space more effectively.

S4. Like it.

S5. Need to be lined up better.

S6. They might work but I prefer buttons.

S7. Very easy to use. A great idea.

S8. The panels in TRAC were severely misaligned making them difficult to use. If they were correctly aligned they would be fine.

S9. Very nice.

S11. If the touch panels are so that they actually push buttons, I think they would be OK. Pilots will have greasy flight gloves on and there can be no uncertainty on the button being pushed. Would a touch panel give a pilot that certainty?

S12. It is hard to find the spot sometimes. This would all get worse in a greasy cockpit. Use pushbuttons.

S13. Too much interference with other buttons.

S14. Can't use them with gloves. It's easy to push the wrong button.